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CAPACITY OF THE UNITED STATES FOR POPULATION

By Professor ALBERT PERRY BRIGHAM
COLGATE UNIVERSITY

IF any reader of these pages thinks, with a recent writer, that "population is a vast and wandering theme," we shall have no quarrel with him. No doubt the problem has a keener interest in such a country as Great Britain or France, where population approaches capacity or is perhaps beyond the permanent limit of resources. But we are maturing, the frontier stage is past, our land is filling and fertile quarter sections are no more free. We have thus our own social problems, sharpening their quest for solution, and, moreover, being Americans, we now and then become enthusiastic and break into prophecy.

We may well sober our inquiry with the preliminary question—is a great population desirable? Not so, surely, for us, from the military point of view. We have men enough to send to the front and men enough to keep in the shop and field, to meet any emergency of war which lies within the horizon of reasonable conjecture. Perhaps, in view of our general influence in the world, we might be glad to have several hundred millions of people, but only if we are so conditioned that our influence would be a boon to other lands. This indeed in itself implies a limit, for we must not be too many to live with freedom and with worthy standards.

We may take ourselves out of the ranks of the enthusiast with a second preliminary question—is a great population probable? Our list of prophets is distinguished. Mr. O. P. Austin thinks there is no good reason for our failing of three hundred million people in the year 2000. Mr. James J. Hill expects an increase to two hundred million in less than fifty years, and Mr. Andrew Carnegie a few years ago thought five hundred million a proper figure. Mr. Justin Winsor allows two hundred million for the Mississippi Valley. Mr. F. A. Ogg raises the figure

by fifty million, and Professor A. B. Hart does not hesitate to go up to three hundred and fifty million. We are by no means disposed to dispute all of these figures, but there are considerations which point in the other direction, as for example that the percentage of increase went down in the decades between 1860 and 1900.

We have also the check of advancing civilization. That voluntary restriction follows a higher scale of needs is shown in France, in lesser degree in Great Britain and probably in all lands of advancing culture. Thus there is color for the view that France with her disturbing birth rate has only arrived first at the condition to which all cultivated peoples are moving. Motives of economy and of opportunity for self and children press more strongly as standards rise, and it has recently been urged that even Ireland, with new land laws and with peasant proprietorship, will become more restrictive of population. It seems to be as true with man as in the general field of natural history, that the higher the type the fewer the progeny.

Perhaps also this tendency will fall in with the natural limit of food production. Indeed, the latter will have a controlling causal effect on the former, following the ever-operative law that higher prices or approaching scarcity is accompanied by restriction of population. That which is temporary in the latter case may well be found permanent in the other.

To the present time immigration has been one of the chief sources of our growth. We are already seeing a check of the inflowing current, and this may well become permanent in future years. The restrictive measures of the government count for something. The narrowing of opportunities, as for free land, is another and more powerful factor, and a further consideration of unknown significance is rising in our view, namely, the improvement of conditions and the triumphs of democratic aspiration in the lands from which the foreigner comes. In proportion as life in the old countries becomes endurable, not to say attractive, the fountains of immigration will begin to go dry.

On the other hand, there is a source of increase upon which we may look with full content, reasons, applicable alike to us, which a European authority has assigned, for the increase of European population during the last half century. These reasons are in relation to the lowering of the death rate by diminution of war, by the elimination of epidemics and by better hygiene. These advances would seem to mean more than a lower death rate. Not only are people kept alive, but they are made more productive workers and reasonably, it would seem, may become more prolific as well as better conditioned. Whatever our views of population or progress, it would hardly be prudent to disagree with Mr. Mackaye's proposition that it is not so important to get nitrogen into the soil and raise more food as to make right use of the food we have. We should, he thinks, avoid undue increase of our population,

raise our wealth per capita, and not "cause two unhappy human beings to live where one lived before."

It is proposed here to attend more to the means of approaching the problem, than to the study of figures, which last in writings on population, are usually guesses supported by vague and inapplicable comparisons with China. As the writer has said elsewhere, it is not of interest to know how many Chinese could exist on American soil, but how many occidental citizens could live here in comfort and progress.

The largest single element in our problem must always be food. Other things are important, but for simplicity we take this singly, in relation to the resources of our own domain. There are several ways in which our food supply can be increased, and first of all, without raising the sum of products, they can be enlarged in their availability. No one familiar with culinary matters can avoid the belief that there is great loss through misuse and positive waste. Unskilled treatment alone is responsible for much loss of nutritive values and prodigality is to be found on private tables, while consumption in public places is attended oftentimes with destruction that is well-nigh criminal. The rise of industrial and domestic science will in part correct the evil, and any ultimate approach to a narrow margin between food and mouths would be felt in resulting economies.

No one doubts that our food supply could be much increased by more scientific and intensive cultivation of lands which are now actually under the plow. Here indeed we are already beginning a cheerful and significant era of hope and achievement. The farmer is becoming a wiser man and many things are helping him in his unfolding. This came home to us recently in the story of a farmer in western New York, who started poor four years ago, has paid for a large farm property with four crops, and expects out of the fifth to build a mansion for his family.

The American farmer is learning to adapt his crop to his soil and to his market. This is the teaching of the United States Bureau of Soil Survey, in its field work and in its reports. It is the burden of the agricultural college and of the experiment station, and the agricultural explorer of the department in Washington is searching widely in aid of something fit and good to fill every arable American acre. Adaptation will increase the product of food, as will also the more intelligent and energetic use of fertilizers. Intelligence will find the fertilizer and put it where it will do the greatest good, and will stimulate the energy in its use which is now sadly lacking. Let any man traverse the country regions in the eastern states and he will pass innumerable poor and hungry farms, and the greater the natural leanness of the soil, the more sure is he to see the manure-heap leaching, often for the second year, in the farm yard.

In like degree are our resources now wasted through the prevalent

methods of sewage disposal. No treachery to the land can be so great as that which sends out into the sea the highly concentrated nitrogenous products which have with toil been wrung from a soil which is becoming poor in capacity for crops. In this primitive riddance of valuable matter we accomplish a further loss by polluting the waters and if we do not thus endanger human life, we destroy the fields in which a certain important amount of aquatic food can be produced.

A further gain can be had on soils already in use by expert management in the direction of proper succession of crops and a thoroughness of occupation and tillage often seen in Italy, France or Belgium, but only exceptionally found as yet in our own land. We need not only better directed labor, but more labor on the same soil. In the regions of sufficient rainfall, which comprise nearly the eastern half of the United States, we shall find, or did find in 1900, seven men per average square mile, tilling the soil, or one to each lot of 91.4 acres. Making generous allowance for ground not in tillage, we still find the working force far too small to bring maximum quantities of food out of the ground. We need also on much plow land and meadow east of the arid belt supplementary irrigation for many seasons and for some crops, and with abundant water resources, there is no good reason why nature should not thus be helped to her best. Some areas, many, it would doubtless be better to say, would be doubled in productive worth by more effective drainage than has yet been applied. The barest inspection of crop averages per acre, or of half the ripening harvests that fall under the eye of the traveler, supports the belief that a vast increment of food can be won from lands that are not now given a full chance.

Further inquiry leads us to lands not now cultivated, which might and will be made productive. Here some of our largest reserves appear. Lands of an arid or semi-arid character embrace about two fifths of our territory. In these great fields, and in small patches now improved, crops can not be expected unless water is applied by man. There is doubtless force in the claim that these soils are potentially marked by exceptional richness, due not only to the fact that they are virgin soils as related to man, but because they have not suffered the leaching and waste of important elements which have affected soils in lands of large rainfall. It is cited by Hilgard that Nile lands have for centuries supported an average population of more than one and one half persons per square acre, which means a density of about 1,000 per square mile. Without questioning the accuracy of this claim, it may be urged that we do not know whether flooding by the Cordilleran irrigator would be as favorable to fertility as the flooding of the Nile. Nor may we forget comparative standards of living any more than in the case of China.

We must also keep in sight the inevitable condition that there is water enough in the west to make fertile but a small fraction of the dry area. If we accept this at one fifteenth and receive without discount

the figures for the Nile, applying them boldly to Arizona, Colorado, Nevada and the other arid states, we shall arrive at a population of eighty million for the arid regions. The eastern man will incline to think this conclusion savors of fancy, and the Cordilleran enthusiast will in like manner think it sober and sensible prophecy. All will agree, however, that the food production of the country willl rise by a marked increase when reclamation work has been carried toward its maximum. Whether many millions or several tens of millions will thus be added to our numbers is not important to our present purpose. That the growth will be large none denies.

A further great gain will be made in the drainage of our marsh lands, both of the marine and of the fresh-water type. That this is in no way theoretical appears in the vast European areas, which, though now densely peopled, were more or less covered by water a millennium ago. Professor Shaler counted that the area of swamp lands rises to more than 100,000 square miles, reckoning only such marshes as would be considered reclaimable in northern Europe, and he believes that they would be equal in production to the three states on the north bank of the Ohio River, Ohio, Indiana and Illinois. When one remembers the quality of a drained swamp, and that the area of available marshes is about three fourths as great as these combined states, he will have no difficulty with this conclusion.

The importance of this reserve has recently been accented by the proposal of Senator H. C. Hansbrough, to make these marshes also subject to reclamation by federal action. Further emphasis is warranted by the easy proximity of many of these lands to great eastern markets, and by their adaptation to the intensive culture of many crops.

We may be challenged in the statement that forest lands of some extent may yet be spared for tillage. The writer yields to no one in loyal conviction of the importance of forest conservation, or in condemnation of congressional delay and inaction. Ultimate adaptation will control in forest conservation, and some lands will be cleared for needful and effective tillage, and their loss will be counterbalanced by the foresting of other areas where unfitness for the plow is now evident.

We shall also replace forest products in a more extended use of underground materials for buildings and implements. As in Europe the clay pit and the quarry will afford means of curtailing the forest. Likewise the use of the fibers of grain plants for the making of paper will release timber for other uses or timber land for other crops. We need also to remember that the remaining forests will be properly conserved and made largely and permanently productive. When, forty years ago, the Irish laborer planted his potato patch by the railway track, or when to-day the Italian immigrant raises his vegetables in waste corners, it has not been recognized that he is the pioneer of the future. It is the traveler in such foreign lands as Belgium, Norway or Italy, who becomes able to appreciate the waste of American soils.

Beyond the plowed fields of the present, the arid and wet lands and the superfluous forests, are no inconsiderable reserves of food from lands deemed useless. We may consider potential gardens along more than two hundred thousand miles of railway, the fruit that might grow by millions of miles of highway, the steep and immature slopes that are more capable of terracing than those of Capri or Amalfi, or ancient Palestine, and finally those rugged areas of glacial hillside or mountain slope, where nut-bearing trees might produce no inconsiderable amount of highly nutritious food. The possible production of food substances in the laboratory is at present so far from the geographer's domain that it would be profitless to dwell upon it.

It is plain that the whole circle of conservation problems applies here, not only by directly increasing food, as in irrigation, but in cheapening the cost of transportation, in saving land by forest conservation and in utilizing power of every kind to the full, thus releasing time and energy for the free use of opportunity and the complete employment of all our resources. Thus a well ordered civilization would sustain the greatest number at good standards, as a well-managed household may maintain a large family on a lesser sum than is required by a neighboring small household.

Population capacity would afford a less baffling inquiry if food alone were needed. Mere questions of mouths, bushels and pounds might involve simple ratios, easily determined, but we must at once include clothing, of vegetable fibers, animal fibers, furs and skins, nearly all requiring land for their production. Man must have shelter and a long catalogue of objects of domestic utility, for the household and for the tillage of the soil. These things may become chiefly derivable from subterranean sources with the single exception of a minimum demand on the forest. Many rocks and mineral substances would far outrun any possible use of them, but it seems certain that we could not for many generations supply iron for as many millions as we can feed. It may be doubtful whether our ultimate expansion will receive its first effective check above or below the surface of the earth.

We must include also a wide range of objects of public utility, such as roads and all appliances of transportation and manufacture, and public structures for education, worship, government, health and charity, adding instruments of knowledge and pleasure such as books, music, ornaments and all works of art.

Almost as fundamental as food is the requirement of power. Here, however, the supply seems ample and permament. Long before the stores of buried fuel are exhausted, other natural forces, particularly that of moving water, will meet the needs of any population which we can feed. The maximum of population therefore for the whole world hinges upon the supply of material substances derived from the atmosphere, the water, the soil and the rocks.

For a given country the problem is complicated by exchange. The exchange values, however, must be won on the home ground. England has, for example, a far greater population than she can feed, but her coal and iron have enabled her to manufacture and to carry for other nations. But England is now to a considerable extent using foreign supplies of the ores of iron. For a period she may do this and maintain her industry, through inertia, but imported raw materials and fuel could not permanently afford a basis for British industry, and for the present population of the United Kingdom. In that future, whenever it may come, the islands will contain the people whom they can feed, clothe and shelter, and no more.

Total resources, therefore, rather than total food production, determine how many people a given country can support, but in the world aspect total food marks an absolute limit, since we can not bring in food from Mars, even if Mr. Percival Lowell should convince us that she had a surplus.

It would be interesting to consider the United States in the light of the principles that have been suggested, but the story would be too long. We might simplify it by adopting the interesting and pleasant belief that our extraordinary range of resources would enable us to get on with little exchange, but this, as we have seen, would hardly change the result as to population. Mr. O. P. Austin supports our hopes of three hundred million people by the comfortable assurance that we can grow all our sugar, all our rice, wine, tea, silk fibers, tobacco and most tropical fruits. Probably we could get on without diamonds and there are those who think our civilization might survive without coffee. But it would really make little difference whether we raised coffee or bought it with the proceeds of wheat. Or we might, indifferently, raise our silk, or sell farm machinery and buy silk, since either sort of production at present requires trees, and trees require land.

We have ventured the belief that we are sure of power. We may further include hopefully the resources of the underworld of the rocks, considering new reductions and uses of metals and many mineral substances. When the use of wood has come down to the minimum, the chief remaining demands on the soil, may, after all, be for food and clothing.

If we further suppose war and heavy armaments eliminated and all government honestly and economically administered, we shall cover a vast present waste. Thus to arrive at maximum population we must somewhat approach millennial conditions. Then, in high degree a self-sufficient nation, we could keep as many people as our own soil could feed and clothe. With wise timidity we have been deferring those large transactions in figures which the reader has been expecting, and we might with good show of reason, confess that inquiry for precise results is absurd and drop the attempt to forecast. Nevertheless, the next patriotic speech will marshal before us our future hundreds of millions,

sole progeny of buoyant national pride. Perhaps, therefore, any sober argument on this inevitable theme is better than none.

Probably the safest approach is by comparison, for thus we avail ourselves of such experience as has come to our race in different parts of the world. But let us avoid China and Java, even though they seem such available examples of a great population, of high density, with small percentage of exchange and hence almost self-sufficient. But their standards of living—could we, even with our superior skill and progressiveness, take the same resources and support an equal number of people up to American standards of comfort and efficiency? We do not know those resources well enough to tell, hence we dismiss oriental nations and turn to people more like ourselves.

We have elsewhere made a brief comparison between England and that part of the United States which lies east of the Dakotas, Kansas and Texas. It was suggested that this region, about two fifths of the chief continental area of the United States, averages in resources of every sort as well as England, and it was shown that if we could in these 1,200,000 square miles reach the present density of England, we should have, east of the meridian of Omaha, 742,000,000 people. To have put this in print should at once, it would seem, shatter all pretension to soberness. We are quite willing to scale down the figure, while taking refuge under the fact that these computations were not offered as prophecy. With such an enormous population, we, like England, could not feed half our mouths, and should have to exchange other products for food. But other lands might not have the surplus in those days, to send to us. And our underground resources might be seriously reduced, if not exhausted, and we could not produce the exchange values. We thus see how fascinating and how futile is the hundred-million tendency. Let us divide our total by three, and arrive at a population which we might hope to feed from our own soil, a little under 250,000,000. It will be seen that in this estimate we leave the Great Plains and Cordilleras to be peopled according to the dictates of a cold conservatism, or of a lively enthusiasm.

An instructive comparison can be made with Italy, whose area is 110,550 square miles, and whose population is reckoned to have been, on January 1, 1907, 33,640,710. The density was 304.3, not far from half that of England or Belgium, and about twelve times as great as that exhibited by the United States in 1900.

We may first take the comparative density of agricultural workers. In Italy, of persons, male and female, over nine years of age, there were at work in the fields, in 1900, 9,611,003. In our own country in 1900 there were, over ten years of age, 10,438,219. When we remember that the smaller country contained a little more than 30,000,000 people at that time and we had 76,000,000, the figures show their meaning. This comes out with force if we look at the ratio of workers to a given surface of production. In the United States east of the arid regions there was

one worker to each 91.4 acres, counting the entire territory. In Italy there was one to each 5.07 acres, counting only the productive lands. But as these are there reckoned at more than two thirds of the whole, the comparison stands almost at full force. Including all of Italy, we should find one worker for each plot of eight acres or a little less.

Making all due allowance for primitive methods and smaller individual efficiency, we still see how much more intensive is the care of the lands. And we must not forget that in Lombardy and some other parts of the Mediterranean kingdom, modern methods are gaining ground. Indeed that nearly two thirds of the country is worked as productive soil is in itself significant to one who knows the ruggedness of much of the realm. The stretches of bare Apenine slope seem to be endless, and one is sometimes inclined to say that Italy is fertile only in spots. It has been called a "gray rather than a green country," a designation which must stand true except for idealizing imaginations which require Italy to unroll fields of endless verdure. One must traverse the Val d'Arno, or cross and recross the plains of the Po, find the fertile corners of south Italy and Sicily, and then explore the terraced mountainsides and secluded Apenine valleys, to learn how the little kingdom feeds so many people. If we are reminded that the people are poor and the comforts of life small, we recognize the fact, often sad and depressing, but even here, when considering capacity for population, we remember that Italy has lost by long use of her soils, and by much injury through deforestation, no small measure of her ancient capacity for food production. We, on the other hand, have a virgin country and on the whole our spirit of conservation has arisen in time to save us from fatal losses.

The value of Italian products, as reported, for tillage, animals and forest, is annually about $1,000,000,000. This figure, however, does not include the items of poultry, eggs or vegetables. These, and especially the last, are no doubt far more important relatively than in our own country. The above figure gives a little less than $30 in value for each person in the kingdom. This indeed would seem a starvation figure, but for the vegetables, whose rapid succession of crops and large consumption, must be a large factor in maintaining so great a density.

The comparison turns greatly in our favor when we consider underground resources, and here her paucity makes Italy instructive for population study. Gold and silver are so small as to be negligible, and yet she must acquire her reasonable sum of these metals. Sulphur is far in the lead, but amounts annually to but little more than $7,000,000. Zinc follows with $4,000,000, lead with a little more than one and one half million and all the others fall below the last figure. Iron gives an annual value of $1,371,155, and employs but 1,790 workers. Mineral fuel stands at $838,375, a small fraction of the mineral fuel output of the single state of Iowa. Coal and coke are imported to the extent of about $40,000,000, and boilers and machinery cross the fron-

tier to the value of $32,600,000. The total annual mineral output of Italy is about $20,000,000.

When we remember that Italy imports much of her food as well as iron, coal and other things, we are pressed with the question—where does she get her exchange values? Five of her imports pass the hundred million lire mark. These are wheat, raw cotton, coal and coke, boilers and machinery and raw silk. But one export passes this mark, viz., raw silk, rising, however, to nearly 600,000,000 lire. There are, indeed, many exports of smaller value, but these are more than offset by minor imports, so that, as a whole, her imports exceed her exports by nearly 600,000,000 lire, or by about 33 per cent. It is not easy to see how Italy maintains her people. Certain reliefs suggest themselves. It is admitted that many Italians exist rather than live; but this must not be said of Rome or Tuscany or the valley of the Po. We allow something for a genial climate which at once gives quick returns from the soil and reduces the need of clothing and fuel. And we may not forget the great sums brought into Italy by travelers and foreign residents, for the winning of whose money Italian arrangements sometimes seem peculiarly effective. However difficult it is for one not trained in economic studies to see how this thing is done, it is done, and conditions are improving. We are thus warranted in looking to this middle kingdom of the Mediterranean for lessons concerning ourselves.

As has been already intimated, 70.6 per cent. of Italy is registered as productive, the rest being barren or negligible. Let us consider the territory of the United States east of the arid regions. We will (let us hope to be forgiven) eliminate New England, the Appalachian Mountain belt, the Appalachian Plateau, the interior timbered region and the Ozark Hills. The lands thus thrown out as relatively poor contain 28 per cent. of the area under consideration, which it will be seen is not far from the 29.4 per cent. rejected in Italy. And they contain 30,000,000 people, which is not far from the population of Italy. We have left a vast expanse of prairie, alluvial and lacustrine lowland, and of coastal plain. We may at least please our fancy by giving these selected lands the density of Italy. The resulting population is about 334,000,000. Adding the present population of the rejected areas, we have a total east of the arid belt, of 364,000,000. If we allow half the density of Italy for this entire area, we have a total population east of the arid belt, of 230,000,000.

We have just referred to a classification of lands which is comparatively new. For some years physiographers have seen that new categories were needed in the description of continental surfaces. The forms of the land have been taken into account, in respect both to their origin and to their present characteristics. A plain is more than a plain for it may be of a variety of origins and types, with its peculiar phases of structure, relief, soil, climate and vegetation. Similar statements

may be made of plateaux and mountain regions. In the census of 1900, this classification was taken up in a brief and supplementary way, and the area, population and density of the several physiographic regions were computed and are placed before the reader. The areas are not exact, for the boundaries had to be determined by the nearest available county lines, but the error can hardly be of disturbing proportions.

It is not here possible to exhibit or discuss the interesting facts brought out by this new departure of the census. It marks, however, a step of progress in understanding the adjustment of our people to their environment. Under the designation of New England Hills are included New England, the Adirondacks and the foothill country east of the Hudson in the state of New York. The density for this region is the highest in the United States, 124.1. How strongly population turns on other factors than soil, thus appears, and the result becomes astonishing when we put down in comparison the present density of the prairie region, viz., 29.2.

Using the new land classification, we may approach again the possible or probable population east of the great plains, or in the well-watered eastern section of the United States. Leaving out the New England Hills, which already exceed the density we are about to propose, and omitting the Appalachian Plateau and the Ozark Hills, it would seem reasonable to expect an average density of 100 for the remaining territory of the east. This is about the density of Europe. The territory for which we propose it includes the coastal plains and lowlands, the Appalachian Valley, the piedmont and lake regions, the Mississippi alluvial region, the interior timbered region and the prairies. One need not apologize for thinking this aggregate physically as good as average Europe. Two of the regions, the Appalachian Valley and the piedmont, already have more than three fourths of the density proposed, and the interior timbered region, so far from being the wilderness implied by its name, has a density of 68.7. Raising the whole to 100, we pass from the present 53,800,000 to 127,600,000. If to this total we add the present population of the New England Hills, the Appalachian Plateau and the Ozark Hills, we bring our total to 145,000,000. If we allow reasonably for the growth of these three regions we place the figure at 150,000,000.

A density of 100, however, seems a low expectation for the prairies, and also for the lake region, which last already has 55.2 persons per square mile. Considering the soil, climate, minerals and transportation facilities of the lake borders, their population must largely increase. Give these two regions the present density of France or of Austria-Hungary, we must add to the total already reached, 40,000,000 for the prairies and 15,000,000 for the lakes, bringing our total east of the great plains to 205,000,000.

Iowa is a typical prairie state and has 55,475 square miles, not counting a few hundred miles of water surface. This state has about

two and one fourth million of people, and with the density of France would have more than four times as many, or nearly ten and one half million. Iowa now has 13.39 acres of improved farm land for each one of her population. With the greater density she would have about three acres for each person, while France now has two and one third acres. In general fertility the odds are probably in favor of Iowa.

The mineral output of France is now relatively much greater than that of the prairie state, but it is by no means certain that the ratio would be maintained under full development of the new region, whose building stones, clays and gypsum are but in their commercial beginnings. In that prime necessity, coal, Iowa has quite the advantage, for she mines annually 2¾ tons for each resident, against ⅛ ton in France. The latter people imports much fuel, while the vast resources of Iowa for the most part lie still beneath the surface. Not many are probably aware that Iowa has 7,000 square miles of forest, more than at any previous time within the ken of the white man. She has, indeed, nearly as much forest for the proposed ten million people, as France now has for an equal number. It seems reasonable, therefore, to forecast for the prairies an occupation as dense as that of France or Austria.

It would be fatal to the peace of any student to omit the west in such a discussion as this. The writer recently made before the International Geographic Congress at Geneva what seemed to him the moderate and innocent assertion, that the center of our population would always remain some distance east of the geographic center of the United States. He was sharply reminded by a fellow American that such sentiments openly expressed on the Pacific Coast would make him the subject of a lynching excursion. As he is at present at a safe distance he retains his view, but is willing to accept tentatively a generous prophecy for the Cordilleras. Suppose we take seventy-five per cent. of the figure already hazarded for the areas of reclamation, or 60,000,000. And that we may not seem to be dominated by cramped eastern notions, let us concede, since no data are available, that when the arid lands are turned into paradise and a full trade established up and down the Pacific and across its wide waters, that the coast and its cities, the wet belt of the border, the mining centers, mountain valleys and arid pastures will harbor an additional 40,000,000 people. This allows 100,000,000 people west of the prairies, a region that in 1900 had a population of 4,654,818 and a density of 3.5. Here is an increase of twenty-one and a half times, a proposal which can hardly be charged with parsimony, and raises our total for the whole country to 305,000,000. If we think the Cordilleran estimate out of bounds, it would yet be easy on the basis of European comparisons to find place for compensating millions in some of the geographic regions east of the Mississippi River.

PEALE'S MUSEUM

By HAROLD SELLERS COLTON, Ph.D.
UNIVERSITY OF PENNSYLVANIA

AN almost neglected chapter in the history of the natural sciences in this country is that dealing with Peale's Museum.[1] Of the accounts of the museum that have appeared from time to time, one alone is worthy of consideration, being written from a scientific point of view. The work referred to is by Mr. Witmer Stone[2] and considers the ornithological collections alone.

Through the great kindness of Mr. Horace Wells Sellers, access has been had to the diaries, letter books and unpublished autobiography of Charles Willson Peale. With the material thus furnished by Mr. Sellers, to whom the writer is deeply indebted, and much other material from the Pennsylvania Historical Society and the Philadelphia Library, very little of which has been referred to by biographers, many clouds enveloping the history of Peale's Museum have been cleared away. As this history is so intimately connected with the life of the founder, a better beginning can not be made than by reviewing briefly his career.

His life was a long one—eighty-six years. It divides itself very naturally into four periods—of about equal length—twenty to twenty-four years: the period of youth, the period of the prime of life, the period of middle age, and the period of old age. The first period begins with his birth in Queen Anne County, Maryland, April 15, 1741.

His progenitors were English. In the paternal line, they were for several generations rectors of the parish of Edith Weston in Rutlandshire. Charles Peale, his father, although educated in turn for the church at Cambridge, did not take a degree, but came to this country and became headmaster of the Kent County Free School in Maryland. Although the school was popular and patronized by the best families of Kent County, yet he, at times, had great difficulty in making both ends meet; and died when his eldest son Charles Willson Peale was nine years old. His widow, being left with very little to provide for a large family, removed to Annapolis, and, by dressmaking, maintained herself and her children.

[1] The official name was "The Philadelphia Museum," but must not be confused with the now existing "Philadelphia Museum," which was founded forty-five years after the former ceased to exist.

[2] *Auk*, April, 1899, Vol. XVI., pp. 166–177.

Charles was now put to school; but, after he had learned writing and arithmetic, etc., he was apprenticed, at the age of thirteen, to a saddler. Working out his apprenticeship, when he was twenty-one he married into an influential family; and, with the assistance of a life-long friend of his father, James Tilghman, set up in business for himself.

The saddlery business did not prove a success; and it was about this time that he, on seeing a poorly executed painting and having had from childhood a taste for drawing, thought that he could paint as well. With some borrowed colors and by the aid of a looking glass, he painted a portrait of himself with such good results that some of his friends advised him to study painting seriously. Thus, at the age of twenty-four, he began the second period of his life—that of a painter.

Peale, the Portrait Painter

After studying under the best available talent in Maryland and in Virginia, he went to Boston and took a few lessons under Copley and shortly afterward was engaged to paint several portraits. Returning to Annapolis, his work soon became noticed. John Beale Bordley and several of his fellow members of the Governor's Council of Maryland made up a purse and sent Peale to London to study under Benjamin West. Returning to Maryland two years later, his ability was soon recognized and for the next twenty years he was the leading portrait painter of Pennsylvania and the south.

His many engagements in Philadelphia caused him to move to that city in 1774 and to make it his permanent home. Being an ardent patriot, he offered his services to the American cause at the beginning of the Revolution, being made lieutenant and later captain in a company of Philadelphia militia. He was in action in the battles of Germantown, Trenton and Princeton. At Valley Forge in the winter of 1777 he found occupation in painting portraits of his fellow officers. Many of his portraits painted during the war were subsequently placed in his "painting room" to form a nucleus of what he hoped would become a national portrait gallery. During this period, his interest in public affairs led him into various activities and public positions in connection with the British evacuation of Philadelphia.

As soon as opportunity offered, he established himself in a house at Third and Lombard streets and resumed with his former energy the practise of his portrait painting. In connection with this house he built a long room to hold his pictures and to use as a studio. As curiosities Dr. Morgan gave him some bones of a mammoth from Ohio; Professor Robt. Patterson, of the College of Philadelphia, presented him with a paddle fish from the Allegheny River; Dr. Franklin gave him an Angora cat from France, which was soon lost for want

of proper means to preserve it; with these as a nucleus, it was suggested to Peale that he start a museum of natural history.

The Museum

At the age of forty-four the third period of Peale's life may be said to begin. Acting on the suggestion that he form a museum of natural history, he at once referred to books to discover the means to preserve reptiles, quadrupeds and birds. At the end of the second summer those preserved were all eaten up by dermestes and moths. After a great deal of experimenting, a method was devised that fills many pages of his autobiography. The basis of this method was the use of arsenic and alum. Although it had a very serious effect on his health for awhile, yet he was obliged to use it. "The many difficulties I had encountered in this new business," said he in his autobiography, "had made me often repent that I had undertaken so arduous a task, yet . . . the idea of handing down to posterity a work, that if judiciously managed might become equal to any undertaking of the like kind in Europe"—this was a stimulus to his exertions. Although, by the neglect of his portrait painting, he found it difficult, at times, to meet the expenses not only of his family, but of taxes, ground rents and other unavoidable expenses of his establishment, yet his enthusiasm, perseverance and ingenuity enabled him to conquer the difficulties, but not without the aid of his talents as a painter. Finally, after placing his museum on a self-supporting basis he retired in 1808 to his country place, "Belfield," in Germantown.

In the midst of the active period of museum development he made trips when his funds were low into all the neighboring states to paint. During his trips he never lost an opportunity to gather specimens or further the interests of his museum. On a trip to Maryland he met a Rev. Mr. Kerby who was a collector of beetles. His account, in his diary, of the effect of this meeting shows the enthusiasm that was instilled into his collecting. Said he:

> Some collectors, like myself, have only looked for subjects large and striking to the sight, but now I declare that I find equal pleasure in seeking for an acquaintance with those little animals whose life, perhaps, is spent on a single leaf, or at most on a single bush. It is diverting to watch a flower as you approach and see the little being watching you. It turns around a twig or part of a flower to avoid your sight, and in an instant drawing in its legs rolls off, sometimes falling from leaf to leaf to get a passage to the ground.
>
> Yesterday morning I set out to walk several miles before dinner. . . . But in the first meadow I found myself examining the bushes attentively and there I found so much amusement that several hours passed away before I could think of leaving those bewitching animals. Looking at my watch, I found it was almost dinner time, when I scarcely thought I had begun my pursuit.

The museum grew rapidly and soon he was obliged to seek for other quarters. Being a member of the Philosophical Society, some of his

friends suggested that he rent Philosophical Hall. This the society allowed him to do, making him curator and librarian. In describing the moving of the collection he writes:

To take advantage of public curiosity, I contrived to make a very considerable parade of the articles, especially those which were large. As boys are generally very fond of parade, I collected all the boys of the neighborhood. At the head of the parade was carried on men's shoulder's, the American buffalo, the panthers, tiger cats; and a long string of animals carried by the boys. The parade from Lombard Street to the Hall brought all the inhabitants to their doors and windows to see the cavalcade. It was fine fun for the boys. They were willing to work in such a novel removal and saved me some expense in moving the delicate articles.

Governor Mifflin allowed Peale to fence in part of the State House Garden so as to make a place to keep living animals. Speaking of this, Peale said:

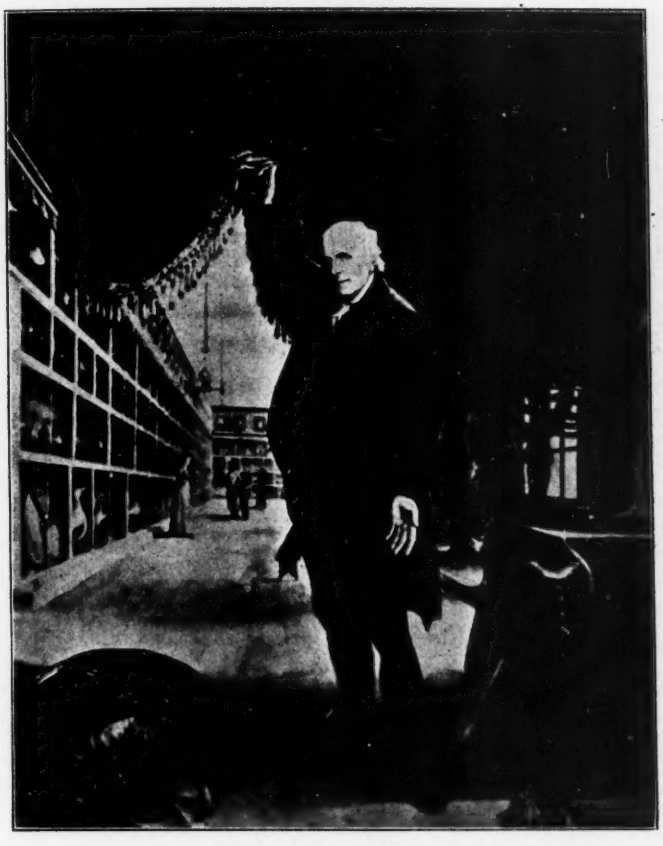
The cages and animals kept in the yard amused the public much, but was supported with some expense; yet it was a necessary appendage to the museum, as animals that had not come to their full growth are not fit subjects to be preserved, except when some of the young are to be placed with their parents to form family groups, as pictures of the manners of animals.

Notwithstanding legends to the contrary, this was the only zoological garden that Peale ever attempted to form, it being but a temporary expedient.

It was not Peale's practise to sell his duplicate specimens; but wherever opportunity offered he would exchange. In this way he was soon in communication with the various museums of Europe and from his letters I find that he sent many specimens to the Museum d'Histoire Naturelle, to the British Museum, to the Royal Society of Sweden, and many others scattered over Europe.

It must be remembered that during much of this time Europe was at war. Privateers scoured the seas, which made many letters go astray and caused many cases of specimens to be lost. Notwithstanding these troubles he mentions receiving an orang-outang and a "Platipus," and many other beasts from all over the world.

"Now to show all these things to advantage," said Peale, "required judgment as well as a tasteful disposition of them to be pleasing to the eye as well as useful to enquiring visitors." In classifying animals he followed Linnæus. In fact he was such an admirer of Linnæus that he named one of his children after the great Swede. He used Buffon's work to identify the specimens. However, as one would expect in a new country that had been visited by but few naturalists, much of the material gathered by Peale would be classed as "non-descripts." To these Peale gave a common name but did not describe. It fell to the labors of Wilson, Say and other Philadelphia naturalists who followed to describe those animals. As arranged in the cases each animal had on it a label that gave the English, French and (when one had been given to it) Latin name.



CHARLES WILLSON PEALE.

With respect to the arrangement of the specimens on the shelves Peale says:

> It is not customary in Europe, it is said, to paint skies and landscapes in their cases of birds and other animals, and it may have a neat and clean appearance to line them only with white paper, but on the other hand it is not only pleasing to see a sketch of a landscape, but by showing the nest, hollow, cave or a particular view of the country from which they came, some instances of the habits may be given.

This idea is interesting because it is the one that is growing in favor in the museums of Europe and America at the present time.

Peale and His Contemporaries

In 1792 Peale writes:

> Having exerted myself to my utmost ability to collect and preserve articles for the museum and believing I could get men of distinction to form a board of visitors and obtain legislative aid for the further improvement of it so that at last it might become a great national institution, I waited on several gentlemen.

As a result of this, a board of visitors or directors was formed of twenty-five individuals. Thomas Jefferson was elected president, and among the others present were Alexander Hamilton, James Madison, Thos. Mifflin, Robert Morris, David Rittenhouse and Dr. Caspar Wistar. In the registration book of season ticket holders for the year 1794, the first signature is that of George Washington, who signed for four tickets. Then follow the names of John Adams, Munroe, etc. The fact that he was able to procure the aid of such men and the fact that he was allowed the use of Independence Hall rent free for a time and later for a nominal rental, all show that the museum was recognized as a valuable institution.

The decades 1790–1810, during which Peale was most active, composed part of the period of American zoology called by Brown Goode[3] the period of Jefferson. The influence that the great statesman exerted Goode compared to that of Agassiz in a later period. Among the medical profession of the country were a few men interested in natural history. These centered about the newly founded medical school of the University of Pennsylvania. The ones only that might be placed in a class with Jefferson were Caspar Wistar and Benjamin Smith Barton. Later may be mentioned the names of Wilson, Ord and Rafinesque.

At this time the pure sciences centered around the American Philosophical Society. The minute books of the society show that from the time that Peale was elected a member in 1786, he was rarely absent from a meeting. Renting, as he did, a large part of the hall and being librarian and curator, he was for many years closely identified with it.

In 1804, Baron Humboldt, Bompland, the botanist, and a Peruvian gentleman, Montrefar, arrived in Philadelphia from the famous trip to South America. Peale was a member of an informal committee from the Philosophical Society to see to their reception. The committee went with the travelers to Washington, where they were entertained by President Jefferson. Of this journey Peale writes to his brother-in-law in New York:

> However, I have been richly repaid for the expense and trouble of a journey, by the agreeable conversation of Baron Humboldt, who is, without exception, the most extraordinary traveler I have ever met with; he is a fountain of knowledge that flows in copious streams; to drop this metaphore, he is a great luminary diffusing light in every branch of science, I say diffusing because he is so communicative of his knowledge, which has been treasured up in his travels of upward of nineteen years.

The Baron sat before Peale for his portrait and on sailing for France Peale presented him with a mounted specimen of an alligator. This

[3] G. Brown Goode, "Beginnings of American Science," *Proc. Bio. Sci. Wash.*, Vol. IV., 85.

later was presented on the Baron's return to France to the National Museum.[4]

With the Museum d'Histoire Naturelle, Peale had more intercourse than with any other institution in Europe. This began when the museum in Philadelphia was very young, by the arrival in Philadelphia of the naturalist, Baron Palisot de Beauvois, a refugee from the terrible massacre at St. Domingo. For the short time that he was in Philadelphia, Beauvois aided Peale in many ways. Not only did he help Peale in identifying the specimens,[5] but he also wrote the French edition of the catalogue; and Peale in turn aided him by furnishing him with many letters of introduction whenever he went on collecting trips into other states. A personal friendship sprang up which lasted till Beauvois' death in 1820, and it is in Peale's letters to Beauvois after the latter's return to France that one finds the best account of what was going on in Philadelphia. With respect to the museum, Peale was in correspondence with Geffroy St. Hilaire and with Cuvier, also receiving letters from Lamarck. With all these connections joining the museum to France it was not strange that the French influence was strong.

The Mastodon

The feat which was Peale's greatest achievement in connection with the museum was the recovery and reconstruction of the skeleton of a mastodon. In the spring of 1801, receiving information from a scientific correspondent in the state of New York that the bones of a mammoth had been found in digging a marl pit near Newburg, Peale hastened to the spot; and, after bargaining with Mr. Masten, who owned the farm on which the bones were found, he finally paid $300 for those bones that had already been procured and the right to drain and excavate the morass to recover if possible the rest of the skeleton. On Mr. Masten showing Peale the spot where the bones were found, which was a spacious hole filled with water, he wrote in his autobiography:

> The pleasure which I felt at seeing the place, where I supposed my great treasure lay, almost tempted me to strip off my clothes and dive to the bottom and try to feel for bones. The hope, however, of returning soon with the means of emptying the pond satisfied me.

He went at once to New York. Through President Jefferson he was able to borrow pumps from the Navy Department and other things from the War Office. The Philosophical Society advanced him $500 without interest, with his house in Philadelphia as security. He then returned to the scene of operation with his son Rembrandt. After

[4] Hamy, E. T., "Alexandre de Humboldt et le Museum D'Histoire Naturelle," *Nou. Achhis. Du Mus.*, 4e series, Vol. VIII., p. 10.

[5] Cuvier, "Eloge de M. de Beauvois," *Mem. Paris Acad. Sci.*, IV., 1819–20, p. 318.

INDEPENDENCE HALL, Philadelphia, which contained Peale's Museum.

hard work they were rewarded with grand success and were able to ship to Philadelphia one skeleton that lacked principally the lower jaw and the top of the head. What was lacking in this skeleton was found in another from a nearby bog. The bones of the two animals were not mixed. When the skeletons were set up the missing parts were carved out of wood, so that there were finished two complete skeletons. "Although putting these skeletons together," to return again to the autobiography, "was a long and arduous work; yet the novelty of the subject, the producing the form, and, as it would seem a second creation, was delightful; and every day's work brought forth its pleasure."

Up to this time many scattered bones and teeth of the mastodon had been found in this country. They had been described as belonging to a race of gigantic man, to the fathers of cattle, to hippopotomi, etc. In a letter to Geffroy Saint-Hilaire describing his find Peale states that this animal should be called the carnivorous elephant of the north, but should not be confounded with the Siberian mammoth. Cuvier in his memoir "Le Grand Mastodonte" writes:

> Mais pendant que nous travaillions ainsi en Europe sur quelques fragmens de cet animal, M. Peale continuait à en recueillir les os, et il avait été assez heureux pour en obtenir deux squelettes presque complets qui ont décidé la question pour tonjours (p. 261).

The Museum in the State House

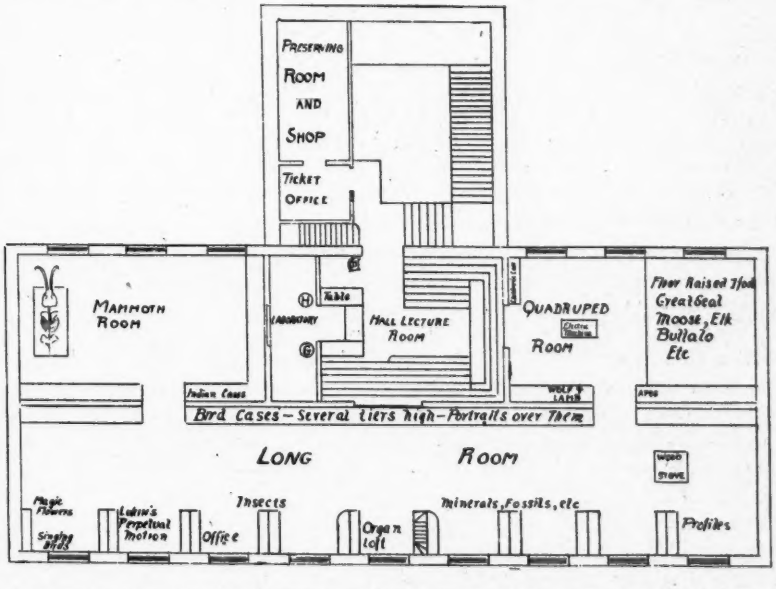
In 1802 the state legislature moved to Lancaster. This left the State House (Independence Hall) vacant. Peale petitioned the legis-

lature and was allowed to occupy the building as long as he allowed persons to pass through the hall into the State House Garden. His son Rembrandt used the east room on the first floor as his studio, while the entire second floor and tower was given up to the use of the museum.

The best picture that we have of the museum in Independence Hall is found in a letter written by the late George Escol Sellers, of Chattanooga, Tenn., a grandson of Peale, who as a boy and a young man spent much of his time in the museum, and who subsequently became one of its trustees. The period referred to in this letter is about 1820–1824, twelve years or more after Charles Willson Peale ceased to take an active part in the management, Mr. Rubens Peale being in control. There is very little evidence that much of scientific value was added after the father retired, except, perhaps, the collections of Major Long's expedition to the Rocky Mountains, and Dr. Harlan's anatomical and craniological preparations.

Mr. Sellers, in describing the arrangement of the hall writes:

> I will go with you up the stairs and try to lead you through the Museum rooms. At the top of the stairs is a small window where tickets to the Museum are sold. We enter a great door from the landing and find ourselves in what was called the hall lecture room. The bench seats rose all around at such an angle that the two or three upper seats crossed the passage into the Quadruped Room at sufficient height to give headway under them. To the right is a door that is worthy of consideration. (This door leads into the Quadruped Room, the south-west Room of the State House.) On the west end of the room, the



GROUND PLAN OF PEALE'S MUSEUM IN INDEPENDENCE HALL ABOUT 1821 TO 1826.
From a diagram drawn by Mr. George Escol Sellers, from memory.

floor was raised about 1 foot and on it stood the great seal, Buffalo, Elk, Moose, Bears, etc., but most attractive to country folk was a 5 legged cow giving milk to a 2 headed calf. As we turn to the passage into the long room, the great case at our right hand is the wolf case. The great gray wolf with bloody fangs is rending a lamb, whose papier-mache entrails from the skilled and realistic hands of Uncle Rubens bulge out so naturally that they appear living and in motion. The opposite case was of particular interest to children. Smaller animals crowd the cases that fill this room.

Of the Long Room Peale himself has perhaps given us the best account.[6] He writes:

For instruction to those who wish to know the Linnean classification of Birds on the side of the door entering the Long Room, is a large frame containing the several orders and genera of Birds with the characters of each. This Long Room has an elegant appearance. Its length is 100 feet. It is handsome because of its regularity of the numerous glass cases, which are neat without being gaudy and the catalogue in the frames makes a beautiful division covering each of the shelves extending from end to end of the room. There are 9 windows opposite, between them projecting are partitions to hold the cases of insects and also cases for minerals and fossils.

Over the center window is a neat well tuned organ for the use of such visitors that understand music. Under the orchestra are microscopes for showing Insects and other subjects to advantage.

Over the Bird cases are two rows of portraits of Distinguished Personages in gilt frames extending almost the whole length of the room. They are original portraits painted from life by C. W. Peale and his son Remb[t] At each end of the room are also some portraits. The most conspicuous being those of General Washington and his lady, which are the last they sat for C. W. Peale.

To complete the description of the museum we return to Mr. Sellers' letter:

If the day be chilly, the settees are around the great six plate wood burning stove. This was a very attractive feature. This Long Room was a promenade to show off finery, gay bonnets and cashmere shawls. Most of the more modern paintings and the portraits painted by Uncle Rembrandt when in Europe for the Museum were in the Mammoth Room.

On entering this room in the corner case was a wax figure of Col. Lewis or Clark, I do not remember which, in a complete Indian costume. The cases of Indians and their dresses and implements were very attractive. Back of the skeleton of the Mammoth at the end of the room was a large, what might be called, historical painting showing the tread wheels and other appliances that were used to pump out the morass while the bones were being exhumed. In fact this and a smaller painting gave a graphic history.

The marine room, up the lobby stairs, better known as the anatomical room was really a gruesome room in spite of its end cases of Monkeys at work. There was shown the smith, the carpenter, the cooper and even the shoe maker, a shoe between his knees, his arms akimbo as if drawing tight his waxed ends, a grin from ear to ear. The side cases were shallow and filled with snakes long and coiled. One snake was charming a stuffed bird with its bead eyes. One was in the act of swallowing a toad or frog with the hind quarters projecting from the mouth. There were also lizards big and little. Among the various cases was one filled with real anatomical preparations, including a

[6] See footnote, p. 231.

ghastly tatooed head, a manufactured South American Mermaid—half fish and half hairless dried monkey—, innumerable alcoholic preparations, also an embryo shelf with animal and human fœtuses.

In 1805 Peale started to write a book called "A Walk with a Friend to the Philadelphia Museum."[7] This seems never to have been finished and was never published. A comparison of the above account of Mr. Sellers with that of Peale shows that on the whole the same specimens were on exhibition as in the days that Mr. Sellers recorded; nevertheless there was a lack of sensational attractions in 1805. As an instance of this may be mentioned the fact that the monkeys at work were not added until 1809, a year after Peale retired to his Germantown farm. The two-headed calf was not added for some years after that.

In "A Walk with a Friend" Peale writes about the quadruped room, and it is of interest in relation to modern methods of taxidermy:

The door opens to us and behold a multitude of animals fills the room on every side. They seem to be in characteristic attitudes; the Lama of South America is rearing up in the act of spitting through the fissure of his upper lip. . . .

The muscles of this as well as many of these quadrupeds are so well represented that painters might take them for models and all is so well preserved that no insects can destroy them; a thing too generally the case in other museums.

The Proprietor has invented a mode of mounting them which I believe was never practised before. As the muscles can not be preserved to keep their natural plumpness nor can it be expected that the most careful operator can stuff skins in the common way to preserve perfectly the true form more especially of animals that have not an abundance of hair or fur—the limbs of these have been carved in wood; closely imitating the form after the skins had been taken off; giving swell to the muscles proportional to their action so that, in fact, they are statues of animals with the real skin to cover them—a stupendous labour originating from and effected by an enthusiastic desire of exhibiting a series of real forms as they exist in nature. . . .

Besides the methods of taxidermy as practised by Peale, there was another equally striking innovation. We have seen that there was a large frame illustrating Linnæus's classification of birds. To aid the inquiring visitor much information of general interest was contained in similar frames. In the Mammoth Room on the wall beside the skeleton of the Mastodon, Rembrandt Peale's "Historical Disquisition on the Mammoth" was framed page by page. By reading this account and by referring to the skeleton and to the paintings Peale intended that his visitors should have the opportunity of becoming well informed. These were points the importance of which were emphasized by Brown Goode[8] many years afterward.

[7] Manuscript in the Pennsylvania Historical Society.

[8] See Brown Goode, "Museum History and Museums of History," 1889, p. 267.

As an attraction, one winter when the attendance was low, Peale installed in one corner of the hall a man to cut silhouettes by a new method. In one year 8,880 people carried away likenesses of themselves. After he retired, but particularly after his death, under the direction of his sons this precedent that Peale himself established of having attractions was increased, so that in its last years the institution became little more than a dime museum.

In the library of the Pennsylvania Historical Society there is a large blank book bound in whole calf entitled "Memoranda of the Philadelphia Museum." This book contains a record of the donations, accessions and exchanges between the years 1803 and 1837. An impression that one gets from reviewing its pages is that of the enormous amount of valueless material presented by travelers from Europe and from farmers up in the state. This, however, is a common feature of all museums; nothing offered must be refused, but, if of no value, will find its way to the official rubbish heap.

The library of the museum must have been of exceeding value. Every page records books bought or books received in exchange. As an exchange for specimens sent to France the museum received Buffon's works in five volumes. The following is a sample page showing the type of entry:

PAGE 12

1806 Feb. 17. A Tropic Bird, 2 Frigates, 3 Eels which are said to wound very severe and to attack people. Ship Geo. ᶜWashington by Capt.ⁿ Farris.
The natural history of British Insects with colored plates Vol. 1st —octavo,—John Armond.

19. Fossil shell from Kentucky, they are found from 1 foot to 50 feet below the surface of the earth in limestone. W. Chambers.
2 pieces hog skin, one inch and ¼ in thickness, from the shoulder. It was shot on the banks of the Ohio, in the spring of 1793—William Chambers.

21. The head of the Petrel F. V. Riviere.

21. Phæton Athireus or tropic bird, female, F. V. Riviere.
Lacerta Chamæon, Chameleon, Isle of France—Capⁿ Farris.

21. Skeleton of a Porcellaria Petrel. Samuel Coates.

22. The Trumpet Fish from S. America—Peter Solee
An Experimental Dissertation on the Rhus Vernix, Rhus Rodicans and Rhus Globrum commonly known in Pennᵃ by the names Poison ash, Poison-vine, and common Sumach by Thoˢ Horsfield.
An Inaugural Dissertation on the warm Bath by Hen. Wilᵐ Lockette.

24. Viverra nasua Coata Mondi (alive) from South America Joseph Baker.

His Last Years

Peale's early training and natural ingenuity enabled him to turn his hand to anything; this quality has been exaggerated by his biographers and mere incidents pointed to as periods in his career.

Peale's period of senescence may be said to date from the time he

resigned the active management of the museum and moved to his "Belfield" place, at Germantown. With him old age was robbed of its infirmities. Temperate habits, outdoor exercise and constant employment of mind and body, were responsible, according to his own theories,[9] for the vigor that he enjoyed at eighty. He was eighty-three when he painted without his glasses a full-length portrait of himself by order of the trustees of the museum. This is the portrait that now hangs in the Academy of Fine Arts in Philadelphia, an institution of which he was the chief founder. These latter years of his life were not marked by reduced activities, but by more varied occupations. His attempts to make porcelain teeth and similar undertakings have been unduely emphasized. Undoubtedly it is the memory of this period that has led many of his biographers to refer to him as a "jack of all trades."

Later History of Museum

It may be interesting to outline briefly the later history of the museum and the fate of its collections.

In the first decade of the nineteenth century the value of the collections was from an educational point of view equal to those of the famous museums of Europe. At this time, with a view to its preservation and to carry out a cherished hope, Peale offered it to the government at Washington to form the nucleus of a National Museum. According to Jeffersonian simplicity it was not in the province of the government to father institutions not directly connected with government, so the offer was refused.

In 1816 the city purchased the State House from the state; and, at once, raised the rent on Peale from $400 to $2,000. As Peale could not pay so much, a compromise was made for $1,200. The museum was run at a loss for three years, at the end of which time Peale induced councils to lower the rent to $600. About this time Peale offered the museum to the city on condition that they would agree to house, add to it, and promise not to sell any part of it except duplications. The city refused to accept the gift.

In 1821 the museum took another lease of life, and its aged proprietor, still fearing that it would become divided on his death, had it incorporated with five trustees, all, except one, members of his family. As organized, four professors were appointed to give lectures in Natural History, viz.:

In mineralogy,	Dr. Gerard Troost.
In zoology,	Thomas Say.
In comparative anatomy,	Dr. Richard Harlan.
In physiology,	Dr. John Godman.
Conservator in zoology,	Titian Peale.

[9] "An Epistle to a Friend on the Means of Preserving Health, Promoting Happiness, etc.," 8vo, Philadelphia, 1803, 48 pp., by C. W. Peale.

The publishing of a journal was undertaken which perished after the appearance of the first number.

In 1827 Charles Willson Peale died and the next year the museum moved into the Arcade on Chestnut Street above Sixth Street., on the north side. In 1835, the stock of the company was increased from $100,000 to $400,000 and a magnificent building was started at Ninth and Sansom on the site of the present Continental Hotel. Three years later the collections were moved from the Arcade into their new home.

Up to this time the museum had been very prosperous financially and had become largely a money-making concern. In 1841 the failure of the United States Bank carried down the Museum Company. The receivers of the bank foreclosed on the building, which was soon sold at auction. By paying rent the Museum Company was allowed by the new owner to occupy the building. In the hard times that followed, the Museum Company attempted to keep its head above water by vaudeville attractions and concerts. Thus the museum was thrown into direct competition with the dime museum as typified by Barnum's Museums. The directors of the company were not equal to competition with the trained showman. When, in 1846, the end came, the collections were sold at auction, the pictures going all over the country; yet one third subsequently came back to Independence Hall.

An attempt was made to keep the Natural History collections together; and until 1850 they were exhibited at Masonic Hall, but not by the Peales. At that time they were sold by the sheriff and bought for five or six thousand dollars by P. T. Barnum and his associate, Moses Kimball. They were divided, half going to the Boston Museum and half going to Barnum's American Museum, in New York.[10] Legend has it that the mastodon went to this latter place and was destroyed when, in 1865, the American Museum burned. Since its whereabouts[11] was not known in 1852 when Warren wrote his monograph, it is possible that it was burned in the fire that destroyed, in 1851, Barnum's Philadelphia Museum. If this be the case it would seem to indicate that Barnum did not take all his share of the specimens to New York as he said he did. In either case it was destroyed.

In 1900 the Boston Museum broke up, and the specimens were presented to the Boston Society of Natural History, where about 1,300 of the birds now are. There is nothing to indicate that any specimens were added to the collections after they were removed from the Philadelphia Museum.

[10] P. T. Barnum, "How I Made Millions"; the life of P. T. Barnum, written by himself.

[11] The bones mentioned by Warren as being exhibited in Paris belong, I judge, to a mass of bones of several animals which were found at Big Bone Lick. An attempt was made to sell them to Peale. As they were from several animals he refused to buy them. Cf. "The Navigator," Pittsburg, 1811, 7th edition, p. 117.

The second mastodon found in 1801 has had a more varied history. In 1803 Rembrandt Peale and his brother Rubens carried it to England. It was exhibited before the Royal Society. While in London, Rembrandt Peale wrote his "Historical Disquisition on the Mammoth." An attempt to sell the skeleton to Napoleon was undertaken, but war broke out with England which prevented the deal being completed. Peale's sons brought it back to this country and they made a southern trip, exhibiting the mastodon as far south as Charleston. Later, in 1813, Rembrandt started a museum in Baltimore[12] on similar lines to that of his father's in Philadelphia. In this museum the mastodon found a home. This became later the Baltimore Museum, from which in 1846 it was purchased by Dr. Warren and taken to Boston for comparison with his very perfect skeleton and placed in the Warren Museum on Beacon Hill. With Warren's mastodon it was bought from the Warren estate by J. P. Morgan and is now in the American Museum of Natural History in New York, and is called the Baltimore mastodon. This is all that is known of the fate of the collections of Peale's Museum.

A point that has been particularly confusing to historians is the fact that Peale's Museums were located in both New York and Baltimore. In this connection it will become necessary to refer briefly to Peale's sons.

In the last decade of the eighteenth century Rubens Peale and his brother Rembrandt attempted to found in Baltimore a museum with some duplicate specimens given them by their father. This museum was discontinued after one year.

In 1813, however, Rembrandt Peale, who was a better artist than his father, but was less of a naturalist, moved to Baltimore and in the following year opened a museum and art gallery on Holliday Street in a building that afterward became the Baltimore City Hall. The museum finally passed out of his hands, becoming the Baltimore Museum, which was bought by Barnum in 1845. In the early twenties Rembrandt opened a museum in New York, on Broadway, opposite the City Hall. This museum passed out of his hands into that of a stock company, which, after trying to compete with Barnum's American Museum, was obliged to sell out to the great showman in 1842.

When Charles Willson Peale retired, he placed his son Rubens in his place as director of the Philadelphia Museum with the secret hope that with the opportunities at his disposal he would become a naturalist of world-wide reputation. However, Reubens was apparently not much of a naturalist, but during the years that he was director he devoted himself to making the museum self-supporting rather than increasing the value of its collections. For a while, it would seem about 1841, at

[12] Scharf, "History of Baltimore."

the call of the directors of the New York Museum, he became manager of it.

The sons of Peale who had real tastes in zoology were both of the name of Titian. Titian Peale, by Charles Willson's first wife, was becoming a naturalist of great promise and of great help to his father, when he died at the age of eighteen. In memory of this son Peale named a child by his second wife Titian. This Titian became an ornithologist[13] of some distinction, and was conservator of the collections of the Philadelphia Museum for many years.

Peale as a Museum Director

As we have seen, Charles Willson Peale was an enthusiastic collector. The object of these collections was the education of the public. Peale's ideas as to the function of museums are best illustrated by some extracts from a lecture introductory to a series of forty that he delivered in the winter of 1800–1801.[14] He wrote that a museum should teach the economic use of animals and plants. Says Peale:

> A farmer ought to know what reptiles best aid and protect the fruit of his labors, and not through ignorance destroy such as feed on animals more destructive to his grain and fruits; nor possess antipathies to those that he ought to cherish.

A museum should exert a moral influence in the community. Said the lecturer:

> An instance of this is in the memory of many of my hearers. The chiefs of several nations of Indians who had an hereditary enmity, happened to meet unexpectedly in the museum in 1796; they regarded themselves with considerable emotion which in some degree subsided when, by their interpreters, they were informed, that each party, ignorant of the intention of the other, had come merely to view the museum. Never having met before, but in the field of battle, . . . now for the first time finding themselves at peace surrounded by a scene calculated to inspire the most perfect harmony, the first suggestion was that as men, they were of the same species and ought forever to bury the hatchet of war. After leaving the museum they formed a treaty. At the request of the Secretary of War, I supplied them with a room. They heard a speech written by General Washington recommending peace. Their orators spoke, and they departed friends.

After giving a brief account of the history of the museums in the world, from the time of Ptolemy Philadelphus, he describes his ideal museum. Says he:

> First let us suppose we have before us a spacious building . . . in which are arranged all the various animals of this vast continent and all other countries. Let us suppose them classically arranged so that the mind may not be confused and distracted in viewing and studying such a vast multitude of objects. Here should be no duplicates and only the varieties of each species, all

[13] See Stone, Witmer, *Auk*, 1899, Vol. XVI., pp. 166–177.

[14] See "Discourse Introductory to a Course of Lectures, etc.," 1800, C. W. Peale.

placed in the most conspicuous point of light to be seen to the best advantage, without being handled. Besides a classical catalogue descriptive of every article in so extensive a museum, there ought also to be a library consisting of the writings of the best authors on natural history from Aristotle down to the present time. A few persons well acquainted with the methods of preserving subjects should be continually employed. Gentlemen of talent should be allowed to deliver lectures in the several branches of natural history. . . . It would readily be conceived that some person should have the superintendence of the museum, under whose directions every addition should be made and the care of everything should rest with him. . . .

Parts of this lecture and the one delivered in the previous winter in "the hall of the University of Pennsylvania," as an introduction to a course of twenty-seven,[15] remind one amazingly of certain portions of the addresses of Sir William Flower[16] and Brown Goode.[17]

Some of the characteristic features of Peale's Museum might be summarized as follows:

1. Its collections were educational rather than scientific.

2. The idea of indicating the natural environment with the mounted specimen, the idea of framing the pages of books (recommended also by Brown Goode), the idea of having diagrams and popular descriptions of the specimens beside the specimens themselves, and the idea of placing those of the 4,000 insects that were too small to be easily observed by the naked eye under permanent simple and compound microscopes, and his methods of taxidermy, all of which approach the arrangement of modern museums of natural history.

3. Although Peale was not the first to give lectures in natural history in this country, yet he was the first to give lectures illustrated by specimens.

The Influence of the Museum

The influence of the museum was wide-spread, but lay not in the direction that the founder had hoped. A perusal of the newspapers of the first decade of the nineteenth century will show that by this time there were a number of museums in every city. They show also that these museums were copied from Peale's Museum, in that they nearly always had a gallery of portraits of heroes in connection with a collection of curiosities. By the first quarter of the century, all had added concerts as an additional attraction. It was not long before the concert developed into a variety theater, although in the case of the Boston Museum legitimate drama was given. In the middle of the century these museums reached their greatest development, such as it was, while Peale's Museum became but a memory. Barnum's American Museum

[15] "Introduction to a Course of Lectures in Natural History," Philadelphia, 1800.

[16] Flower, William Henry, "Essays on Museums," 1898.

[17] Brown Goode, "Museum History and the Museums of History," American Historical Association, 1888, p. 63.

marked the climax. When in 1902 the Boston Museum ceased to exist, this event marked the end of the last museum that obviously was suggested by the Peale Museum, although there are a few dime museums of later date that have managed to survive.

The cause of the fall of these museums lies in the fact that their place has been filled by natural history museums and zoological gardens which teach true natural history in place of the fake natural history of the dime museum. Although Peale's Museum seems to us to-day a very primitive affair, yet, considering the time when it was founded, the institution must be looked upon in a different light. Then there was no other collection of any kind in the country that could be called a museum. Not having any precedent of museum arrangement, the whole evolution was independent.

The museums of Europe exerted some influence, of course, on its development, but they were so far away that the problems that cropped up from time to time had to be solved independently. This accounts of course, for the many original features that were presented.

The importance of Peale's Museum has been largely discredited, owing to the impression left of its latter days, long after its founder's death. One forgets its positive value and influence when it was directed by his energy and intelligent effort. In the decade of 1800–1810 travelers compare the quality of its collections with the museums on the other side of the ocean. After Peale's retirement from its active direction, the museum ceased practically to grow, while those founded much later began their wonderful development.

Although Peale helped but little to advance our scientific knowledge by the collection of facts, yet to him should be given the credit of organizing what was for awhile a great museum and enabling thousands of people to become acquainted with the appearance and the habits of many animals of this and other countries.

THE THEORY OF INDIVIDUAL DEVELOPMENT[1]

By Professor FRANK R. LILLIE
UNIVERSITY OF CHICAGO

ORGANIC development presents two aspects: that of the individual and that of the race, ontogeny and phylogeny (evolution). These are not two separate and distinct series of phenomena; on the one hand, the individual development is to a certain extent a record of the past history of the race, and the promise of future racial development; on the other hand, evolution is not a series of completed individuals but a series of individual life, histories; for the only road from one generation to the next is by way of a complete life history. Individual development is, therefore, not something distinct from evolution; it is a part of the process of evolution itself; the development of the individual is a chapter in the history of the race.

The development of the individual may be pictured as a steadily broadening stream that takes its source in the fertilized ovum and flows on until death. In this analogy the individual would be represented as a cross-section of the stream at whatever stage we were examining. Though such an analogy limps, inasmuch as individual development is never before us as a unit, as a stream may be conceived to be, and can indeed be said to exist only as the successive cross-sections (its past having disappeared and its future yet unborn), nevertheless, it represents very well the steady, unbroken progress of development from the ovum to old age. There may be crises in the development of the individual, as, for instance, when the chick leaves the egg or the pullet lays its first egg, but there are no breaks in its continuity. Successive generations may be pictured as new streams, each taking its source from a particle—a germ cell—from some cross-section of the preceding generation; and evolution may be represented by placing the new source at a different level than the original. For evolution studies we compare cross-sections of different developmental streams (generations) at comparable distances from the sources, and for evolutionary explanation we must examine the entire series of processes involved in the origin of the new source and in the conditions and inherent character of the new developmental stream.

We can not be said to have actual experience of any other form of development than individual development; evolution or racial de-

[1] One of the series of Darwin Anniversary addresses given under the auspices of the Biological Club of the University of Chicago, February 1 to March 18, 1909.

velopment is an inference from innumerable facts and series of phenomena, all of which are bound up together and rendered intelligible by the theory of common descent. We therefore find that the founders of theories of evolution turn to individual development as the court of last resort, as the place where evolution may be detected in actual process. For here is found the link that binds successive generations, here variations arise, whether they be mutations or of the ordinary fluctuating kind, whether they be germinal or acquired; here in the individual life history the Lamarckian must look for the reflection of the experiences of the individual back upon the germ; here the adherents of orthogenesis must find their crucial evidence.

In his theory of natural selection Darwin accepted as given the data of individual development. But he saw clearly that the fundamental phenomena of heredity and variation had their seat in the individual development, and he experienced the need of framing a conception that would bind together the phenomena of hybridization, the various forms of variation, atavism, telegony, regeneration, inheritance of acquired characters and the like; and in his volumes on "Animals and Plants under Domestication" he framed the provisional hypothesis of *pangenesis* to include them all. I shall not attempt to present the details of this theory, but I may be permitted to say that, as a matter of logical arrangement of the assumed data, under the circumstances of existing biological conceptions and of the state of knowledge of the time, the theory was well worthy of its illustrious founder. In its way, it was as original as the theory of natural selection, though some of its fundamental ideas had certainly been anticipated by previous writers.

Nor shall I attempt a critical estimate of the value of the theory in the history of science; but I may be permitted to call attention to certain features. In the first place, the theory was overburdened with certain unnecessary conceptions such as inheritance of acquired characters, atavism and telegony. The elimination of these conceptions immensely simplifies the theory of individual development. In the second place, it rested upon a fundamental conception, that of representative particles, which amounts to a denial of the reality of individual development. And in the third place, it assumed certain biological processes—the existence of specific vital particles of ultramicroscopic dimensions, their radiation from parent cells, and their aggregation in other specific cells in a definite architectural pattern—for which there is not only entire absence of evidence, but which are wholly inconsistent with the known facts of cellular physiology. For these reasons the theory had only provisional importance, as indeed Darwin recognized in naming it the provisional hypothesis of pangenesis.

The determinant hypothesis of Weismann, contained in his theory

of the germ-plasm, includes the assumptions of the pangenesis hypothesis, with those eliminated that were made necessary by the conception of the inheritance of acquired characters. For Weismann's gemmules, or determinants, the assumption of somatic origin was unnecessary, and thus, as Professor Whitman states, the entire centripetal migration of Darwin's theory was eliminated, but the entire centrifugal process was retained. The origin of every character of the individual was explained in the Weismannian theory, as in the Darwinian theory, by the unfolding (it can not be called development) of representative particles. Nevertheless, the theory of the germ-plasm played an important rôle in the development of biological knowledge, for it framed a set of ideas in a manner sufficiently logical and definite to serve as veritable working hypotheses or bases of attack. The immense effect of Weismann's writings on the theory of individual development should not be underestimated.

Physiology of Development

The theories of individual development that we have mentioned bear all the marks of provisional or formal hypotheses. Although extremely ingenious and logical, they are based only in small part on analysis of the actual processes and they offer no real explanation of the phenomena themselves; for they really include all the elemental phenomena and merely sum them up; they are definitions that include the matter to be defined; they amount to a denial of the reality of individual development as truly as did the preformation theories of the eighteenth century.

As a series of processes occurring in nature and accessible to experience, the development of the individual is capable of resolution into simpler biological processes, and these presumably into physico-chemical events in the usual sense. All attempts to make such analyses come under the head of Physiology of Development; and this plan of attack on the problems of individual development, known in Germany as developmental mechanics, is one of the most actively pursued lines of biological investigation at the present time. Physiology of Development deals primarily with specific problems, and the results constitute a critical basis for the appreciation of general theories of both individual and racial development. We shall examine some results and principles of these studies, and consider their application to some theories of heredity and evolution.

1. *Embryonic Primordia and the Law of Genetic Restriction.*—In the course of development the most general features of organization arise first, and those that are successively less general in the order of their specialization. Thus the directions of symmetry of the future organism—the oral and aboral surfaces, right and left sides, anterior

and posterior ends—are the earliest recognizable features of organization of bilateral animals, and they appear while the germ is still unicellular. The distinction between outer, intermediate and internal organs next makes its appearance, each at first as a single tissue. The outer tissue then separates into an epidermal and a nervous tissue, the inner tissue into the intestinal and yolk-sac epithelium, the middle tissue into muscle-forming tissue, connective tissue, skeleton-forming tissue, blood-forming tissue, excretory tissue, peritoneal tissue, etc.

For every structure, therefore, there is a period of emergence from something more general. The earliest discernible germ of any part or organ may be called its *primordium*. In this sense the ovum is the primordium of the individual, the primitive outer tissue the primordium of all structures of the skin and nervous system, the primitive inner layer of the intestine and all structures connected with it, etc. Primordia are, therefore, of all grades, and each arises from a primordium of a higher grade of generality.

The emergence of a primordium involves a limitation in two directions: (1) it is itself limited in a positive fashion by being restricted to a definite line of differentiation more special than the primordium from which it sprang, and (2) the latter is limited in a negative way by losing the capacity for producing another primordium of exactly the same sort. The advance of differentiation sets a limit, in the manners indicated, to subsequent differentiation, a principle that has been designated by Minot the law of genetic restriction. This in a merely descriptive way is one of the general laws of individual development, and in it is involved the explanation of many important data in the fields of physiology and pathology.

But, though primordia are thus restricted, they nevertheless have the very important property of subdivision, in many cases at least, each part retaining the qualities of the whole. Thus, for instance, in some animals two or several complete embryos may arise from parts of one ovum. Similarly, two or more limbs may be produced in some forms by subdividing a limb bud. Thus frogs with six hind legs have been produced by Gustav Tornier by the simple process of dividing the primordia of the hind legs with a snip of the scissors, in which case he found that on each side one part of the primordium produced a complete pair of legs and the other the normal leg of that side. This capacity for subdivision of primordia explains large classes of pathological facts—at the same time it furnishes a problem to the student of the physiology of development which has proved a serious stumbling block.

2. *Principle of Organization.*—I have already indicated the existence of direction and localization in the primordial germ of the individual, the unsegmented ovum; the ovum, as we say, is polarized,

and, not only so, but, in bilateral animals, it is bilaterally symmetrical. This is not usually indicated in the form of the ovum, which is typically spherical, but in the disposition and developmental value of its parts. Here we have one of the most fundamental and least comprehended facts in embryology. It has, moreover, been shown that this property of direction and localization resides in the homogeneous, transparent, semifluid matrix that suspends all the visible particles of the protoplasm of the egg. It is probable that primordia of all grades possess similar properties, and, if this is so, we have a principle that goes far to explain the orderly localization of processes in morphogenesis.

This principle is not farther analyzable at present; but, as it may be found intact in parts of primordia no less than in the whole, it probably rests on a molecular basis. The most ready analogy in simpler phenomena is that of crystallization. The study of fluid crystals has furnished us examples of inorganic molecular aggregates in which direction and localization are given in the whole and also reappear rapidly in the parts when the whole is subdivided.

3. *The Rôle of Cell-division in Development.*—The individual organism begins as a single cell, from which all cells of the developed organism trace their lineage by the process of cell-division. This has been regarded as one of the most fundamental factors of the individual development in the theories of Weismann, Hertwig and others. But important as the process of cell-division undoubtably is in development, I believe that it is impossible to ascribe to it in principle more than an indirect effect: Considerable complexity of development is possible among Protozoa, whose body is unicellular, and some ova may carry out under experimental conditions a considerable part of the early development without a single cell-division. Moreover, the same kind of differentiated structure may be composed of one cell or of many, or of variable numbers of cells.

The physiological value of cell-division is no different in principle in developing than in functioning tissues (using these terms in the usual sense). The general law of relative reduction of surface in proportion to increasing mass imposes a size limit on cells, which can be regulated only by cell-division; an internal principle of regulation of cell-size has also been stated by R. Hertwig and Boveri, viz., a certain relationship characteristic of each species between the amounts of nuclear and cytoplasmic matters, so that increase of initial volume of the former involves increase of the latter, and *vice versa.* Corresponding to these principles, we find that individuals of different sizes of the same species vary not in the size, but in the number of the cells; and this is regulated by variation in the number of cell-divisions in different individuals.

Cell-division must necessarily, therefore, have an immense func-

tional significance in development, owing to the principle of relation of functional area to mass. It has also another very important function as an isolating factor. The localizations that arise, owing to the organization process of which we have spoken, are rendered relatively stable and permanent by the formation of cell-walls. Thus the elements of the mosaic are isolated, and each isolated part has the opportunity to grow into a new mosaic. Cell-division is thus an important factor in progressive differentiation, not as a cause, but as a means.

4. *Environment.*—Environment must be conceived in a somewhat broader sense than usual in considering the individual development. The developing embryo has an environment in the usual sense, consisting of all those external conditions that surround it, some of which enter into its development. But in addition to this *extra-organic* environment there is an *intra-organic* one; the developing embryo is not merely a unit on which an extra-organic environment operates, but it is a living mosaic, each element of which may conceivably enter into the development of any other in the sense of being a factor in the process. Each part of the embryo, therefore, has an intra-organic environment consisting of all the other parts, some of which constitute relatively immediate environmental factors, others relatively remote ones.

To illustrate: nerves arise in the embryo from certain centers and grow out in the embryonic tissues, much as roots grow out in the soil; the muscles arise separately and the nerves grow to them and make the proper connections. Is this due to an innate tendency of each nerve to grow in particular paths and branch according to definite laws, or, on the other hand, is it due to a directive stimulus exerted on the growing nerve by developing muscle tissue? The answer can be given only by a suitable experiment: If an abnormal innervation area were brought into the field of growth of a developing nerve, would the nerve entering the abnormal area follow its normal mode of branching, or the one characteristic of the normal nerves of the transposed area? To be specific: the bud of a leg of a tadpole that has as yet no nerves may be transplanted to any region of the body (Braus and Harrison), and it develops as a leg; but it receives its innervation from the nerves of the region to which it has been transplanted, and the mode of branching of the nerve is that of the leg nerves. We may generalize this statement by saying that any nerve may be made to depart from its normal mode of branching and to branch like leg nerves, by bringing a leg bud into its innervation area at the time that the nerve is still growing.

It will be seen that if this is generally true, the constancy of distribution of peripheral nerves is not due to the transmission of nerve-branching determinants from generation to generation, but is a function of the intra-organic environment in each generation.

The case of the determination of nerve-branching by intra-organic relations does not by any means stand alone. The same principle undoubtedly holds for the development of the blood-vessels, which grow along paths determined by the arrangement of organs and tissues and not according to a predetermined law given in the blood-vessels themselves. Color patterns have been shown in some cases to be determined by intra-organic variable relations, as in Loeb's experiments on the determination of the color pattern of the yolk-sac of a fish, which he demonstrated to be due to the positive attraction of the circulating blood for migratory cells that bear pigment. The development of any color pattern was therefore dependent upon blood-circulation, and the form of the pattern upon the pattern of the blood-vessels. The primordia of the eye or the ear transplanted to strange locations in the embryo induce formations in surrounding tissues that are strange to them and characteristic of the normal eye and ear environment. The origin and growth of motor nerve cells has been shown in my laboratory by Miss Shorey to be dependent in the chick on normal muscle development; so that the anatomy of the central nervous system, no less than the peripheral system, is dependent to some extent on the environment. Regeneration of lost parts is dependent for its completion to some degree on innervation, and the normal development of muscle tissue beyond a certain stage is likewise so dependent. These examples might be increased by others, which, taken together, would show that an immense part of what we call inheritance is inheritance of environment only, that is, repetition of similar developmental processes under similar conditions. The bearing of all this on the doctrine of determinants, that characters of the adult are represented by germs of a lesser order in the germ of the entire organism, is obvious.

Many of the problems of heredity, so-called, are not capable at present of such resolution. We may note some instances of this kind and then attempt to analyze the whole matter briefly. The example cited of transplantation of a leg-bud is of this kind: the transplanted leg-bud does not develop into an arm if it be transplanted to the region of the arm, but into a right or left leg, as the case may be, and this is true no matter how early the stage at which the transplantation may be made. It is not possible to change the specificity of such a primordium by any means yet employed. Moreover, there are many other experiments which show that the primordia of a great many structures are definitely specified even before they can be detected by any method of pure observation. Thus if a portion of the medullary plate of a frog embryo be cut out so as to include in the cut part the region that would form an eye in the course of time, and if then this piece be replaced inverted, it is found that the subsequent development of this area is inverted, not restored to the normal, although no trace of organs

was present at the time of the operation (Spemann). In this case, then, the eye appears in an abnormal position.

Correlative Differentiation.—We have cited a series of cases that illustrate two apparently contradictory principles known as the principles of correlative differentiation and of self-differentiation. The part that these play in embryonic development should be analyzed. The data of correlative differentiation may be placed in two categories, one of *behavior* and one of *metabolic relations*. Considering these separately:

Behavior.—Any case of behavior involves a stimulus, and a response; these imply irritability and reaction capacity. To take a simple case, for instance, the contraction of a muscle, the stimulus may be of a variety of kinds, nervous, chemical, electrical, thermic, mechanical; in any case the response is contraction. The nature of the response is given in the system and is limited by its reaction capacity. The muscle cell does not contract for one kind of stimulus and secrete in response to another.

This principle is elementary in physiology and psychology and it must apply also in the physiology of development. It appears to me that it has not been sufficiently borne in mind by students of the subject. Herbst, for instance, divides developmental stimuli into directive, trophic and formative. The first kind of stimulus determines the direction of growth or migration, and so plays an important part in development, a really great part illustrated in two of the cases cited, viz., the mode of branching of nerves, and the direction of migration of wandering cells. Trophic stimuli are those that affect the rate or amount of growth without altering its specific character.

The conception of formative stimuli implies, if it has any meaning whatever, that the nature of a developmental process is determined by the nature of a stimulus. A case often cited is as follows: the two most fundamental parts of the eye, lens and retina, develop from two entirely distinct primordia, the retina from the embryonic brain and the lens from the epidermis. The retina first grows out from the wall of the brain and reaches the epidermis to which it becomes fused. The latter then produces a lens. Now it was shown for some amphibia, that, if the retina fails to reach the epidermis, no lens forms; therefore, it was argued that the production of the lens is due to a formative stimulus exercised by the retina on the epidermis. But in some other cases the lens forms even if the retina be absent; which does not prove that it arises without stimulus, only that this *specific* stimulus is not needed. And the fact that transplanted optic vesicles stimulate lens formation in strange localities from the epidermis merely shows that this form of reaction of embryonic epidermis is widespread at this stage of development.

The instance is valuable as proving that stimuli are important in

development, but useless as an example of a formative stimulus. Morphogenetic behavior, like behavior in other fields, is not a function of the stimulus as to its specificity, but it is prescribed and limited by the reaction capacity of the system. One example is as good as many. We shall not find this principle contradicted by any of the known data of the physiology of development.[2]

Metabolic Relations.—When we consider to what an extent the nature of every biological character is given in its chemical composition, it can be readily understood that, to some authors, physiological chemistry should seem the complete basis of heredity. The characters of every tissue of the body are absolutely dependent on their chemical composition, and even slight variations in chemical composition may completely alter function, appearance or form. For such a statement examples are entirely unnecessary.

The development of characters in the individual is dependent upon the occurrence of definite chemical reactions, upon their rate and upon their degree of completion. It has been shown that the law of acceleration of embryonic development in correspondence with rise of temperature is the same in principle as the law of acceleration of chemical reactions by temperature increase. Numerous experiments have been made on the character of development in the absence of one or other or combinations of the elements normal to protoplasm, with the aim of determining their rôle in development. Herbst, for instance, has made a series of experiments on the development of larvæ of the sea urchin in artificial sea waters, in the composition of which definite elements are wanting. He shows, for instance, that in sea water made up without calcium the skeleton fails to develop, and that the form of the larva resulting is profoundly modified from the normal. In other experiments the potassium or sulphur, or iron, etc., is omitted from the solution, and the effect on the development noted. Other experimenters have maintained that the presence of specific chemical elements in excess has definite morphological consequences.

As regards complex substances and their rôle in morphogenesis, but little is actually known. Recent results indicate that the egg contains substances of complex chemical composition which are essential for the development of specific parts or tissues. Thus certain experiments consist in the removal of definite parts of the egg containing specific materials; and in the subsequent development specific parts of the embryo are wanting. In other experiments, by Conklin, the transference of definite substances from their normal location by means of centrifugal force is followed by the development of corresponding

[2] Stimuli in the sense in which we use the word involve merely the impinging of energies on the stimulated system; if substantive additions are involved we have more than a mere stimulus, to the extent that substances are added to the system.

specific structures in the abnormal location. These experiments strongly suggest, even if they do not rigorously prove, that such substances are essential ingredients in definite developmental processes.

I am indebted to Dr. Riddle for the following illustration: The various colors of mammals, such as black, brown, red, yellow, are due to chemical substances known as melanins. The chemistry of these substances starts out from a simple colorless base or chromogen, from which the series of colors, yellow, red, brown, black, is derived as successive stages of oxidation. The chromogen base is found in all mammals; the color then would appear to be due to the varying powers of the cells of different individuals to oxidize the given base. Tornier has shown in his experiments on the coloration of Amphibia that the particular color developed is a function of nutrition, varying in the order of oxidation value (as was later ascertained) according to the degree of nutrition. The development or inheritance of color, therefore, can certainly not be due to the presence of black or brown or red or yellow determinants in the germ, assumed for theoretical purposes by some students of heredity, but to a specific power of oxidation of the protoplasm. This faculty in its turn is no doubt capable of resolution into other physiological terms.

We are only at the beginning of the study of correlations of embryonic metabolism. The rôle that the internal secretions of the embryo may play in the processes of development is practically unknown; but we may expect to find here biological reactions of fundamental significance, especially when we consider such phenomena of the adult as the influence of pregnancy on the organism, the possibility of inducing lactation, with all that this implies, by injection of fœtal tissues; the relations between the sex organs and secondary sexual characteristics and indeed the entire habitus of the organism; the influence of a small gland like the thyroid, or the pituitary body, etc. Biochemical reaction runs through every phase of development and is unquestionably the decisive factor in the appearance of many characters of the organism.

Self-differentiation.—The conception of self-differentiation in morphogenesis is a vague and unsatisfactory one. In a sense it is a contradiction in biological terms, for assuredly environment enters into every biological process. On the one hand, the term covers the fact of the specificity of primordia, which means only a certain stability of metabolism and reaction capacity; on the other hand, it may have specific meaning in one large class of developmental phenomena, viz., polarization and localization. If, for instance, the term self-differentiation might be applied to the appearance of definite axes, angles, points and faces of a crystal, it would with equal propriety be applicable to the appearance of polarity, bilaterality, etc., the axes of embryonic development. But if the term should come to hold simply this restricted meaning, then all reason for its maintenance would be gone.

It is not at all certain that it will be possible to reduce all the problems of the physiology of development to such categories as we have mentioned. The subject is full of unsolved problems, but so far as I can see no one has shown any real reason for assuming ultra-physical agencies in any of the events, and there is the same pragmatic reason for refusing to assent to such suggestions, which are made all too frequently, that there is in other fields of science. If we will be consistent, we are driven to the conclusion that the apparent simplicity of the germ is real, that the germ contains no gemmules, or determinants or other representative particles; that development is truly epigenetic, a natural series of events that succeed one another according to physico-chemical and physiological laws; the explanation of the sequence consists simply in the discovery of each of its steps.

Applications

The problems of heredity and variation are included in a true physiological conception of the individual development; but some biological conceptions that have more or less status and reputation are inconsistent with it. Such are the inheritance of acquired characters, atavism, and the theory of unit characters. The first is a familiar problem that I shall not argue anew; the second logically implies the presence of ancestral representative particles in the germ, which is inconsistent with a physiological theory of development. But it is obvious that the facts united under the name of atavism or reversion take their place naturally in a physiological theory of development, as arrests of development, or modification of environment, or in other ways.

The theory of unit characters deserves more attention for it is essentially a modern theory, and counts numerous adherents. This conception has been most sharply formulated by De Vries in his Mutationstheorie. He says:

> **The properties of the organism are constructed of units which are sharply distinguished from one another. These units may be united in groups, and in related species the same units and groups occur. Intermediates between the units, such as the external forms of plants and animals exhibit so abundantly, are not found any more than between the molecules of chemistry.**

Bateson's allelomorphs constitute a similar conception. Such hypothetical elements of organization must be conceived as distinct from the germ on. They can be shuffled about from one generation to another, and can, therefore, be introduced, removed or replaced in the germ cells.

It must be admitted that these conceptions fit certain facts of inheritance in many hybrids fairly well, but the progress of discovery has made necessary the installation of subsidiary hypotheses, so that the most recent conceptions of unit characters are becoming extremely

complex, and it would seem as though the system would soon fall of its own weight. The entire value of the hypothesis consists in the formal approximate expression of certain facts; when it is found that the hypothesis begins to fail even for the classes of facts for which it was originally intended, and that most of the known facts of development can not possibly be expressed in its terms, the entire conception is put on trial.

The weakness in the theory of unit characters is in the use and conception of the term "character.' The term has been prescribed to us by the systematic zoologists and botanists engaged in describing the differences between species; so that "character" really means any definable feature of an anatomical kind that differentiates species; by extension it also means any other differentiating features that can be defined. In the study of evolution and heredity, it is usually only anatomical characters that are in question. Now the study of the physiology of development teaches us that whatever else "characters" may be, they are not units; *they simply represent the sum of all physiological processes coming to expression in definable areas or ways,* and they may thus represent a particular stage of a chemical process, or a mode of reaction of some part. *"Character"* is essentially a static morphological term; in the study of heredity and development we are dealing with biological *processes.* To adapt a phrase of Huxley's: "characters" are like shells cast up on the beach by the ebb and flow of the vital tides; they have a more or less adventitious quality. To give them representation in the germ is equivalent to a denial of uniformity in biological phenomena.

Just as the exact position of each shell on a beach might be fully explained if we knew its full history, so each character has a certain kind of inner necessity as the result of a sequence of developmental processes. And just as in the history of the position of the shell on the beach we should certainly ascribe great importance to the tides and winds, so in the quality of each individual character we should find corresponding vital tides and winds, as regular and lawful as those of the ocean. We do not yet know the secrets of the vital tides; we maintain only that they are the moving forces in development and heredity, just as in physiology and pathology; and every fundamental contribution to the physiology of protoplasm is at the same time, and to the same extent, a contribution to heredity and the physiology of development.

But if these principles are accepted, how are we to explain the facts on which the theory of unit characters depends? The main difficulty lies not in the facts of mutation, for the physiology of this phenomenon already begins to appear from the experiments of Tower and MacDougal, who show that mutations may result from action of

environment directly on the germ cells. The most fundamental phenomena in the unit character theory are unquestionably the segregations of characters that appear in the offspring of hybrids in so-called Mendelian inheritance. In the most typical cases, grandparental characters reappear in definite proportions of the progeny of the hybrid generation. The interpretation, according to the theory of unit characters, is in the hypothesis of purity of the germ cells of the hybrid generation with respect to the segregated characters; which means that the germ cells of the hybrid generation are pure with reference to the contrasting characters united in the soma; in other words, that corresponding contrasted characters can not both remain in the same germ cell, but are segregated in different ones and may thus appear pure in the descendants of a hybrid generation.[3]

We may well doubt that absolute purity of grandparental characters in the offspring of the hybrid generation occurs, and the results unquestionably vary with the environment; but I believe that we have to admit the general principle of segregation. However, the theory of segregation of unit characters in the germ cells is in no way necessary to explain the results; it is in fact inconsistent with the highly variable result; if unit characters were segregated in the germ, we should expect very definite constant results.

If we take our stand on the epigenetic basis and regard the germ cells as no more complex than *direct* investigation would lead us to suppose, then we have to admit that segregation in the germ cells can involve only constituents of the germ cells themselves. But any variation thus induced in the germ cells would be a factor in each process of the development, and would hence tend to influence every character that appears. Such a hypothesis involves the conception that germ cells contain elements capable of segregation; and this is so. Even if the principle of segregation of characters in inheritance had never been discovered, the principle of segregation of germ-cell elements would still hold, for the two discoveries were made absolutely independently.

I refer to the work of Guyer and Montgomery on the chromosomes, which has been followed by a long series of very exact studies. These studies certainly suggest segregation of parental chromosomes in varying proportions in different germ cells. Indeed, I know of no other interpretation of chromosome behavior that is consistent with the facts. Whatever value we may attribute to the chromosomes in cellular physiology, the variable relations established by their differential segregations, even if only quantitative differences are concerned, must involve endless secondary effects in the long series of cell generations that make

[3] Recent modifications of the theory of purity of the germ-cells do not essentially modify the argument.

up the individual life history.[4] It is not impossible that other segregations than those of the chromosomes form part of the germ-cell behavior, but of this we know nothing as yet. In any event, the principle of segregation of actual visible elements of the germ cells has a firm anatomical basis.

It must not be forgotten that the germ is the entire organism and that it passes through development as the same individual; *continuity of individuality is preserved throughout development.* Therefore, if we discard determinant hypotheses and take our stand on a strictly physiological theory of development, it follows of necessity that the transmitted factors of heredity included in the organization of the germ cells must be factors in the development of the entire organism. The so-called Mendelian factors must therefore be of this character, as I have argued elsewhere. That is to say, the segregated factors must be general constitutional conditions effective as factors in the development of every part of the organism. It can readily be seen that specific intensity of metabolism, or of reactivity, and variation in constitutional size of cells may be such conditions. Others no doubt exist, of which sex may be one. The essential thing to recognize is that the heritable and segregable factors, being conditions of the germ cells at the start, can never be anything less than factors of the entire organism at all stages.

Our conclusion is that the theory of individual development must more and more come to be regarded as a branch of physiology proper. The theory of representative particles must be relegated to the class of formal hypotheses whose usefulness is largely outlived. While it may still play a part in speculations on heredity, I believe that it will come to be generally recognized by those who use it as a mere matter of convenience of terminology, and not as an explanation of the phenomena described in its terms, in the sense of being a verifiable part of the sequence of processes in development.

[4] This general argument would stand even if the chromosomes be regarded merely as indices of organization. They at least give us a clue as to what "the organism" is doing at the time in question. This is indeed all we can say of any characters at any period if we consider the matter in a strictly logical sense.

THE ORIGIN OF THE NERVOUS SYSTEM AND ITS APPROPRIATION OF EFFECTORS

By G. H. PARKER
PROFESSOR OF ZOOLOGY, HARVARD UNIVERSITY

III. Central Nervous Organs

IN dealing with the differentiation of nervous organs, the earthworm affords a good example of a simple type of well-centralized nervous system. The central nervous organs in this animal (Fig. 1) consist of a brain or cerebral ganglion situated anteriorly and dorsal to the buccal cavity, right and left œsophageal connectives extending from the brain ventrally to the ventral nerve-cord which stretches as a segmented organ from near the anterior end of the worm over its ventral line posteriorly to the tail. The segments in the ventral cord agree in

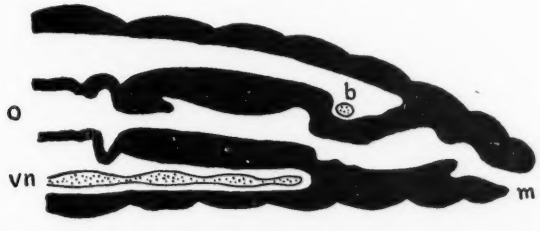


FIG. 1. HEAD OF AN EARTHWORM IN LONGITUDINAL SECTION. *b*, brain; *m*, mouth; *o*, œsophagus; *vn*, ventral nerve-cord.

number and position with those of the worm's body and from each segment three pairs of nerves pass out to the integument and muscles of the adjacent region.

The essential nervous elements of the ventral cord can be made out in transverse sections (Fig. 2). In such sections the integument will be seen to be filled with sense-cells, each of which ends peripherally in a sensory bristle and gives rise centrally, in addition to a few subepithelial processes, to a single nerve-fiber which passes inward between the muscles and enters the ventral ganglion by one of its three nerves; finally this fiber spreads out in the fibrillar substance or neuropile of the ganglion. This cell-body in the integument with its processes including the nerve-fiber constitutes a primary sensory neurone. These neurones usually do not spread beyond the ganglion with which they are directly connected, but in exceptional cases they may extend into the ganglion anterior or posterior to this one.

In the ventral and lateral portions of each ganglion are numerous large nerve-cells from which coarse processes extend through the neuro-

pile, fibrillating as they pass to terminate as motor nerve-fibers in the muscles of the adjacent part of the body. These cells with their processes constitute the primary motor neurones of the earthworm and, like the sensory neurones, they may be present in any one of the three nerves of a segment. Their longitudinal extent is probably not much beyond a single segment.

The primary sensory and motor neurones not only give rise to the nerves of the earthworm, but they contribute a larger part of the sub-

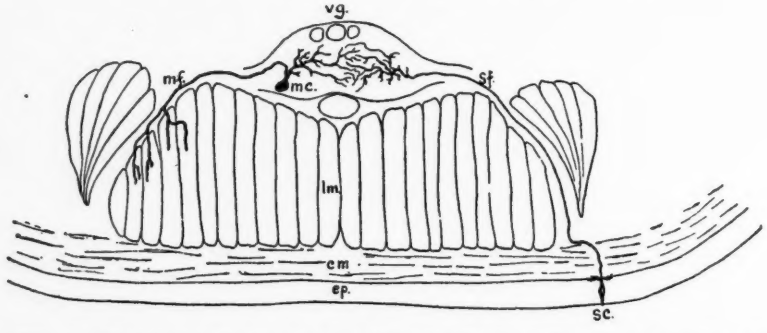


FIG. 2. TRANSVERSE SECTION OF THE VENTRAL NERVOUS CHAIN AND SURROUNDING STRUCTURES OF AN EARTHWORM. *cm*, circular muscles; *ep*, epidermis; *lm*, longitudinal muscles; *mc*, motor cell-body; *mf*, motor nerve-fiber; *sc*, sensory cell-body; *sf*, sensory nerve-fiber; *vg*, ventral ganglion.

stance of each ganglion. As stated in the first article, they form when together the necessary elements for the simplest, conventional reflex-arc. How they are related to one another in the neuropile is not conclusively settled, but, judging from the work of Apáthy (1897) and others, the connection here as in the nervous net is one of direct continuity.

Besides the motor and sensory neurones, the central nervous organs of the earthworm contain a considerable number of so-called association neurones. These are nerve-cells with longer or shorter processes that connect parts within the same ganglion or run from one ganglion to another. They give rise to no fibers that extend into the nerves and hence they are strictly limited to the central nervous organs. Their longitudinal extent is seldom over more than one or two segments.

Since the sensory, motor, and association neurones thus far described make up the bulk of the ventral nerve-cord of the earthworm and since none of these have a longitudinal extent of more than a few segments, it follows that the cord must be conceived as made up of an immense number of overlapping short neurones which in this collective way stretch over its hundred and twenty or more segments. But the nerve-cord of the earthworm is not composed exclusively of short neurones. In its dorsal portion are three giant fibers which, though their nature has been even recently disputed, are without much doubt nervous

organs. The middle and largest of these fibers extends almost the whole length of the ventral cord and, according to Friedländer (1894), has unquestionable connections with ganglion-cells. The two lateral fibers, though smaller, have much the same extent as the median one and are also directly connected with cells. Both sets of fibers connect by branches with the neuropile of the successive segments. Thus the ventral cord of the earthworm may be described as composed of three long neurones and an immense number of overlapping short neurones.

This peculiarity in the structure of the cord makes itself manifest in the movements of the worm. Undoubtedly the slow waves of muscular activity that move over the worm from head to tail as it creeps along are dependent upon the interlocked short neurones, whereas the

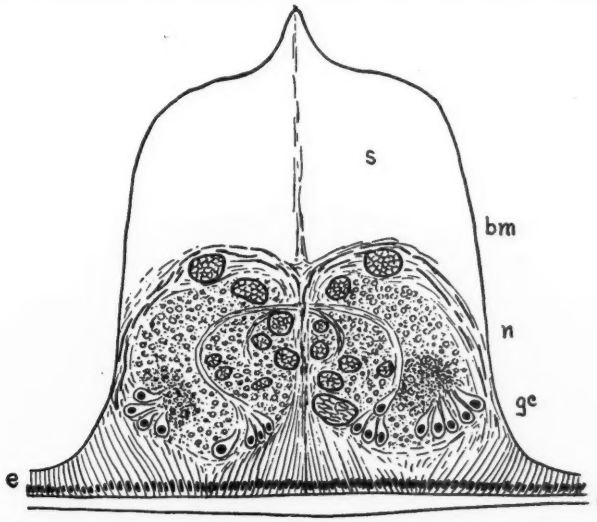


FIG. 3. TRANSVERSE SECTION OF THE VENTRAL NERVOUS CORD OF *Segalion* (modified from Hatschek). *bm*, basement membrane; *c*, cuticula; *e*, epidermis; *gc*, ganglion-cells; *n*, nerve-fibers and neuropile; *s*, space occupied by vacuolated supporting tissue.

sudden drawing together of the worm as a whole, when it is vigorously stimulated, is very probably the result of impulses spread through the long neurones.

The absence of degenerated fiber-tracts in the ventral cords of earthworms that have been cut in two and the rapidity with which nervous regeneration takes place in these worms are conditions that very likely depend upon the almost entire formation of the cord from systems of short neurones.

At first sight the central nervous apparatus of the earthworm seems to be widely different from the neuromuscular mechanism of the cœlenterates, but the difference in reality is not so pronounced. To begin with, the whole nervous mechanism of the cœlenterate is within an

epithelial layer, whereas the central nervous organs of the earthworm are solid masses of nerve-cells, fibers, and neuropile entirely distinct from any epithelium. But this condition is apparently a recent acquisition on the part of the earthworm, for in another annelid, Sagalion, the ventral cord (Fig. 3) and the brain are still a part of the superficial

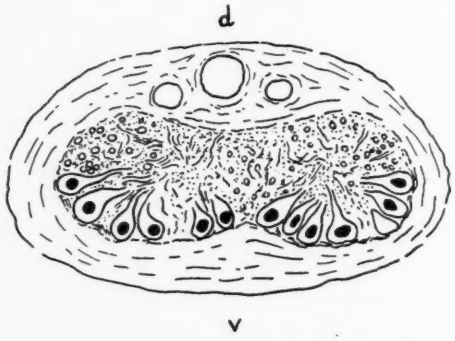


FIG. 4. TRANSVERSE SECTION OF THE VENTRAL NERVOUS CORD OF AN EARTHWORM, showing the ganglion-cells on the ventral side (*v*) and the nerve-fibers and neuropile on the dorsal side (*d*).

ectoderm and differ from the condition in the cœlenterates only in that they represent a concentration of nervous elements in certain regions instead of a diffuse condition as in the sea-anemones, etc. In *Nereis* the brain is epithelial, but the cord by a process of delamination has broken away from the integument, and in the earthworm the whole central nervous system, brain as well as cord, has delaminated. It is chiefly this concentration and separation of the nervous organs from the skin that justifies, in my opinion, the statement that an earthworm has central nervous organs and a sea-anemone has not.

The fact, however, that the central nervous system of the earthworm has developed on the lines of the cœlenterate, has left its mark in the distribution of nervous materials in the ventral cord of this animal. In the ectoderm of the cœlenterate the cell-bodies of the nervous mechanism are nearer the exterior of the animal than are their processes, the fibrillar mass, and the same is true in the ventral ganglia of the earthworm (Fig. 4); here the cell-bodies are on the ventral side of the ganglion, *i. e.*, next the integumentary epithelium, and the neuropile and nerve-fibers are on the opposite or dorsal side of the ganglion. This peculiarity in the distribution of nervous materials is apparently true for most higher metazoans.

Another point of comparison between the nervous mechanism in cœlenterates and in the earthworm is the presence of nerves in the latter and their absence in the former. As already pointed out, the nerves in the earthworm are bundles of independent fibers which course more or less together between their end-organs and the central apparatus.

The fibers in a nerve have no necessary functional relations one with another, but are brought together chiefly by convenience of passage. They are characteristic of those animals in which sense organs and muscles have become well differentiated and widely separated from the central organs, and are not to be confused with elongated bundles of nervous elements such as are to be met with in some cœlenterates and many echinoderms, for though these may represent early steps in the evolution of nerves, they still retain so many evidences of functional interrelation among their elements that they are to be classed rather with nervous nets than with nerves.

The differentiation of nerves as thus defined implies an increased interrelation of neurones in the central apparatus as compared with the condition in the more primitive nervous net. The nature of this growing interrelation has been well expressed by Sherrington (1906) in his principle of the common path. This principle implies that each sense organ may be connected through the central organ with every effector and conversely any effector may receive through the central organ impulses from any sense-organ. In consequence the central organ must contain many common paths which are momentarily used, now for this, now for that combination of particular receptors and effectors. This condition without doubt obtains in earthworms as it does in higher animals, and is a feature that can hardly be said to exist in the nervous nets of the cœlenterates.

It is also probable that the nervous mechanism in cœlenterates differs from that in the earthworm in its capacity as a nervous transmitter. Attention has already been called to the fact that transmission in the nervous net of a cœlenterate may occur in almost any direction and that in the central nervous organs of vertebrates it is very definitely limited and may in fact flow in only one of two apparently possible directions. So definite a restriction can not be asserted for the earthworm but, as Norman (1900) has shown, significant differences do obtain. If an earthworm that is creeping forward over a smooth surface is suddenly cut in two near the middle, the anterior portion will move onward without much disturbance whereas the posterior part will wriggle as though in convulsions. This reaction, which can be repeatedly obtained on even fragments of worms, shows that a single cut involves a stimulation which in a posterior direction gives rise to a wholly different form of response to what it does anteriorly; in other words, transmission in the nerve-cord of the worm is specialized as compared with transmission in the nervous net of the cœlenterate.

There is good reason to believe that the cerebral ganglion or brain of the earthworm is in a measure degenerate. Certainly if we turn to such an annelid as *Nereis* we find in place of the small mass of ganglionic cells and fibers that represent the brain in the earthworm a much

more extensive organ connected with a considerable number of sense organs none of which are present in the earthworm. Eight peristomial tentacles, a pair of palps, a pair of antennæ and, two pairs of eyes are found connected by nerves with the brain of *Nereis* and represent a condition in strong contrast with the unspecialized state in the earthworm. Yet both the earthworm and *Nereis* show much the same traits when deprived of their brains (Loeb, 1894). Each worm is immensely reduced in activity somewhat as a jellyfish is after the removal of its sense-bodies, and one is justified in concluding that the head of even the earthworm is an especially sensitive region through which many slight environmental influences that might not be able to affect other parts of the body gain access at this point to the neuromuscular mechanism. That such a condition should obtain at the anterior end of a bilateral animal has long been recognized as appropriate, for this is the part of the animal that in normal locomotion first reaches the new environment. But I am not acquainted with any discussion as to the mutual relations of the nervous parts at the anterior end of an animal so far as their origins are concerned. If what has been said in these lectures is true, namely, that sense-organs in general precede central nervous organs in evolution, then the brain of the worm has developed at its anterior end because the chief sense-organs were originally there, and not *vice versa,* a statement that I believe to hold for the growth of the brain in all animals. Intricate and marvelous as the brain of the higher animals is, it is, in my opinion, the product of a group of sense-organs that in evolution preceded it in point of time.

The annelids then possess a neuromuscular mechanism in which there are not only primary organs such as muscles, and secondary organs, the sense-organs, but also tertiary organs, central nervous organs. These central organs intervene in position between the receptors and effectors and in the annelids are composed almost exclusively of short overlapping neurones. It is probable that in the sea-anemone these neurones are represented by the so-called ganglion-cells of the nervous layer, but I would not go as far as Havet (1901) and designate these cells in cœlenterates as motor cells, for though some of them undoubtedly connect with the muscle-fibers, others may be purely association neurones. I believe further that in the sea-anemones the fibrils from many sense-cells connect directly with muscle-fibers without the intervention of ganglion-cells.

As an example of a central nervous system built upon the annelid type but with increased complication, we may turn to the arthropods. The central nervous system of these animals, like that of the annelids, consists of a dorsal brain, œsophageal connectives, and a ventral, segmented cord. These organs have been formed by a process of delamination as in the earthworm and exhibit the same fundamental arrange-

ment of cellular elements as is seen in this animal, *i. e.*, the ganglion-cells are on the side of the cord next the exterior, and the neuropile and nerve-fibers next the interior.

The chief fundamental point of difference in the nervous systems of the annelids and arthropods consists in the great number of long neurones in the latter as compared with the former. In the crab, as demonstrated by Bethe (1897), many of the primary sensory neurones extend over half the length of the ventral cord instead of being limited to a few segments as in the earthworm, and the same is true of the primary motor neurones. Moreover, the association neurones have shown an extensive growth. Although in the crab there are some neurones limited to one or two segments, as is the rule in the earthworm, the great majority extend over many segments and often through the whole length of the nervous system. In this way the central nervous organs of these animals are locked together much more closely than are those in the worm and exhibit consequently in their physiology a unity that the worms do not possess. This nervous unity, moreover, has developed to such a degree in the higher arthropods that we may with reason ascribe to such animals as the insects a primitive form of intellectual life not unlike that found in the vertebrates. The structural basis for this seems to me to be foreshadowed in the few long neurones of the worm which, as I have just pointed out, come to be the common type in the arthropods. The type of central nervous system with long neurones also characterizes the other higher invertebrates such as the mollusks, etc.

The central nervous system of the vertebrates and of certain other closely allied forms like the tunicates, is usually put in strong contrast with that of the higher invertebrates. The most striking feature in this contrast is the fact that the vertebrate nervous system is tubular and the invertebrate solid. As is well known, the central nervous organs in vertebrates develop from an ectodermic tube that has been infolded from the median dorsal surface of the animal. This simple nerve-tube with nervous connections, but otherwise almost unmodified, exists to-day in that primitive vertebrate amphioxus. In the higher vertebrates the posterior portion of this tube becomes uniformly thickened and forms the spinal cord, the central canal of which gives evidence of its tubular nature. The anterior portion undergoes still more profound changes than the posterior part in that its wall thickens very differently in different regions and expands in several lobe-like outgrowths, giving rise thus to the brain whose ventricles represent the original cavity of the nerve-tube.

Notwithstanding the striking difference between the central nervous organs of vertebrates and invertebrates, they show certain fundamental similarities and the first of these has to do with the distribution of

nervous materials. Since the nerve-tube from which the central nervous organs in vertebrates are developed is infolded ectoderm, it follows that the inner surface of the tube represents a portion of the outer surface of the animal. This inner surface even in the adult central nervous system is always covered by an epithelium as the exterior of the animal is, and the nervous materials which surround it are related to this epithelium in a characteristic way. This relation can be most easily seen in any transverse section of the spinal cord. Beginning at the central canal of such a section (Fig. 5) and proceed-

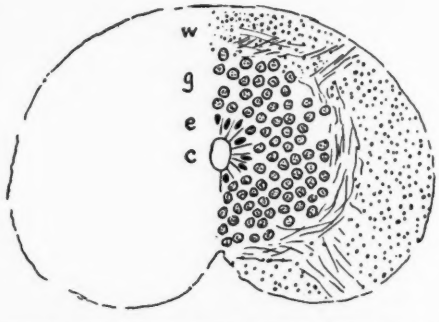


FIG. 5. TRANSVERSE SECTION OF THE SPINAL CORD OF A VERTEBRATE (SALAMANDER). *c*, central canal; *e*, epidermis; *g*, gray substance composed of ganglion-cells and neuropile; *w*, white substance or nerve-fibers.

ing through the substance of the cord to the opposite face, one passes first an epithelial layer, then gray substances composed of nerve-cells, neuropile, etc., and finally white substance made up of nerve-fibers. Precisely this sequence is met with in the central nervous system of any primitive invertebrate such as *Segalion,* where, as already pointed out, in passing through the thickness of the central nervous organ from the exterior to the interior one meets first external epithelium, then ganglion-cells and fibrillæ corresponding to the gray substance of vertebrates, and finally nerve-fibers corresponding to the white substance of these animals. Thus the nervous materials of the vertebrate spinal cord are distributed through that structure on a plan similar to that found in invertebrates, and this plan, though considerably modified, also holds good for the vertebrate brain. So far as these particulars are concerned, the vertebrate central nervous system differs from that of the higher invertebrates chiefly in that in separating from the integument it has carried with it its epithelial mother-tissue instead of leaving this tissue behind.

Not only are the materials of the vertebrate central organs distributed on a plan that is best understood from the standpoint of the invertebrates, but the primary neurones of vertebrates are also most clearly interpreted from this point of view. The primary motor neurones of

vertebrates (Fig. 6) resemble very closely those of invertebrates, for their cell-bodies are within the central nervous mass and their neurites extend as motor nerve-fibers to the skeletal muscles. The primary sensory neurones also agree with those of the invertebrates except that their cell-bodies instead of being in or near the integument, as in most invertebrates, have migrated centrally and thus form the dorsal ganglia. At least this appears to have occurred in all vertebrate sensory nerves except the olfactory, which still retains the usual invertebrate condition.

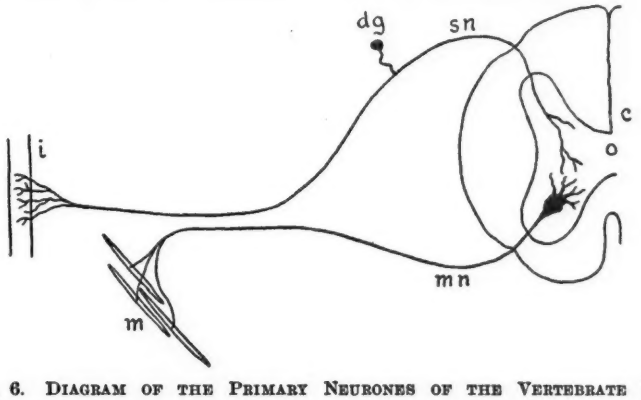


FIG. 6. DIAGRAM OF THE PRIMARY NEURONES OF THE VERTEBRATE NERVOUS SYSTEM AS SEEN IN TRANSVERSE SECTION. *c*, spinal cord; *dg*, dorsal ganglion; *i*, integument; *m*, muscle; *mn*, motor neurone; *sn*, sensory neurone.

Association neurones, which were met with in the invertebrates, are abundantly present in the vertebrates.

How the neurones in vertebrates are related to one another has been a matter of much dispute. Whether the gray substance of the central organs in these animals contains a true nervous net as seems to be the case in many invertebrates or whether their neurones retain greater individuality and are related morphologically only through contact, is not yet settled. That many embryonic neurones, or neurocytes, are in the beginning widely separated from others with which they are ultimately closely related is true and gives color to the belief that they may never fuse anatomically, though physiologically they do become continuous. The fact that nervous transmission through central organs in adult vertebrates is slow, open to exhaustion, and restricted to one direction as contrasted with transmission through nerve-fibers, is strong physiological evidence of a special central mechanism of interrelation between neurones such as Sherrington (1906) has pictured in the synapse. That no special anatomical condition has thus far been discovered that answers to this physiological requirement can in no sense be taken as an objection to it. That the vertebrate central nervous system is in many of its parts a synaptic organ can not be doubted, but that all its parts are synaptic is not yet proved. Possibly this is a

feature characteristic of only the more specialized parts of the vertebrate central organs and entirely absent from the invertebrate, but whether this difference really exists or not must remain for future investigation.

Although it can not be said at present that a synaptic nervous system is the peculiar possession of the vertebrates, there are two important features in which the central organs of these animals differ from those of the invertebrates. In the first place, the central organs of vertebrates exhibit a large prepondernace of long neurones over short ones, and in the second place, they show an enormous increase in the number of association neurones. In an earthworm there are only three long neurones and the rest are short ones; in a crab the long and short neurones are perhaps about equally abundant; but in a vertebrate the long neurones certainly far outnumber the short ones. In any transverse section of the spinal cord of one of the higher animals almost all of the white substance in view excepting a thin layer surrounding the ventral horn is made up of systems of long neurones. In this respect the condition in the vertebrates seems to be almost the reverse of that in worms and in consequence transection of their central nervous organs results in profound and extensive degeneration such as is never met with in animals like worms. For this reason the central nervous system of the vertebrate, though giving much evidence of segmentation in its early stages of growth, is finally a physiological unit such as is realized in no other group of animals, a condition well evidenced by the fact that some of its most recent phylogenetic acquisitions, like the pyramidal tracts of the mammals, may consist of neurones that reach almost from one end of the system to the other.

The second feature that distinguishes the central nervous organs of vertebrates from those of invertebrates is the enormous development of association neurones. These neurones are present in worms, are numerous in arthropods, but are overwhelmingly abundant in vertebrates. Of the white substance seen in the transverse section of the spinal cord almost all except the dorsal columns represent association neurones. Judged from this standpoint there are certainly many more association neurones in the cord than all other kinds taken together. But the association neurones are not only the most numerous in the vertebrates; they also constitute the basis of the most significant evolution. The central nervous organs that show the most conspicuous progressive changes in the vertebrates are the cerebellum and the cerebrum, particularly their cortical portions, and when it is remembered that few or no primary sensory or motor neurones contribute to these two organs, but that they are made up of association neurones almost exclusively, it will be seen how enormously important these neurones become. The association neurones in the vertebrates are not only the organs of intricate nervous exchange, but in the region of the cerebral cortex they

afford the material basis of the intellectual life. Thus in the vertebrates the primary sensory and motor neurones in number and importance are outstripped by the association neurones.

As thus sketched the development of the adjustor or central nervous element of the neuromuscular mechanism takes place in the region between the receptors and the effectors and in time after these two sets of organs have appeared. Its primary function is undoubtedly transmission involving the principle of the common path; secondarily it comes to be a repository of the effects of nervous stimulation whereby its principal function as a modifier of impulses is made possible.

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ANOTHER MODE OF SPECIES FORMING[1]

By LUTHER BURBANK,
SANTA ROSA, CAL.

THE more usual concept of the formation of species is by slow variations so well known as the Darwinian theory, which though attacked from every point, still is and must always in the main be accepted, for without question it gives the fundamental principles of evolution as had never been done before. Yet the boundless amount of research along these lines during the last half century has developed strong new sidelights which illuminate, and in some cases compel a slightly different view of, some of the suggestions of *the master, Darwin.*

During the period of forty years that I have been experimenting with plant life both in bleak New England and in sunny California, extensively operating on much more than four thousand five hundred distinct species of plants, including all known economic and ornamental plant forms which are grown in the open air in temperate and semi-tropic climates, as well as many of those commonly grown in greenhouses and numerous absolutely new ones not before domesticated and on a scale never before attempted by any individual or body of individuals, numerous general principles have pressed themselves forward for discussion and observation. Only one of these can be discussed at this time, and this briefly, more as a text for further observations and experiments than as anything like a full view of this highly interesting mode of species formation.

In the first place, let me say that our so-called species are only tentative bundles of plants, no two individuals of which are exactly alike, but nearly all of which quite closely resemble each other in general outside appearances and in hereditary tendencies. Yet no one can tell just what the result will be when combinations of these inherent tendencies are crossed or subjected to any other disturbing factor or factors. Like the chemist who has new elements to work with, we may predict with some degree of accuracy what the general results will be, but any definite knowledge of the results of these combinations is far more difficult, even impossible, as the life forces of plants and animals act in infinitely more new directions than can any ordinary number of combinations of chemicals.

Only a few years ago, it was generally supposed that by crossing two somewhat different species or varieties a mongrel might be produced which might, or more likely might not, surpass its parents.

[1] Read at the annual meeting of the American Breeders' Association, at Columbia, Mo., January 5 to 8, 1909.

The fact that crossing was *only the first step* and *that selection from the numerous variations secured in the second and a few succeeding generations was the real work* of new plant creation *had never been appreciated;* and to-day its significance is not fully understood either by breeders or even by many scientific investigators along these very lines. Old tailings are constantly being worked over at great expense of time and with small profit, while the mother lode is repudiated and neglected.

Plant breeding to be successful must be conducted like architecture. Definite plans must be carefully laid for the proposed creation; suitable materials selected with judgment, and these must be securely placed in their proper order and position. No occupation requires more accuracy, foresight and skill than does scientific plant or animal breeding.

As before noted, the first generation after a cross has been made is *usually* a more or less complete blend of all the characteristics of both parents; not only the visible characters, but *an infinite number of invisible ones* are inherent and will shape the future character and destiny of the descendants, often producing otherwise unaccountable so-called mutations, saltations or sports, the selection and perpetuation of which give to new plant creations their unique forms and often priceless values, like the Burbank potato produced thirty-six years ago and which is now grown on this western coast almost to the exclusion of all others (fourteen millions of bushels per annum, besides the vast amount grown in the eastern United States and other countries), or the Bartlett pear, Baldwin apple and navel oranges, all of which are variations selected by some keen observer. Millions of others are forever buried in oblivion for the lack of such an observer.

But in this paper I wish to call attention to a not unusual result of crossing quite distinct wild species which deserves the most careful analysis, as it seems to promise a new text for scientific investigation, especially on biometric lines. The subject was most forcibly brought to my attention twenty years ago by the singular behavior of the second-generation seedlings of raspberry-blackberry hybrids. By crossing the Siberian raspberry (*Rubus cratægifolius*) with our native trailing blackberry (*Rubus vitifolius*), a thoroughly fixed new species was summarily produced. The seedlings of this composite *Rubus* (named *Primus*), though a most perfect blend of both parents but resembling neither, never reverted either way; all the seedlings coming much more exactly like the new type than do the seedlings of any ordinary wild rubus. Many thousand plants have been raised generation after generation, all repeating themselves after the new and unique type. No botanist on earth could do otherwise than classify it if found wild as a valid new species, which it truly is, though so summarily produced by crossing.

Since the *Primus* species was originated, numerous similar cases have attracted attention, such as my now popular Phenomenal produced by crossing the Cuthbert raspberry with our native Pacific coast blackberry, and the Logan berry, both of which, though a complete blend of two such distinct species, yet reproduce from seed as truly as any wild rubus species.

I have had also growing on my grounds for some fifteen years or more hybrids of *Rubus idæus* and *Rubus villosus,* both red and yellow varieties. All are exactly intermediate between these two very widely different species, yet both always come true intermediates from seed, generation after generation, never reverting either way.

By crossing the great African "stubble berry" (*Solanum guinense*) with our Pacific coast "rabbit weed" (*Solanum villosum*) an absolutely new species has also been produced, the fruit of which resembles in almost every particular the common blueberry (*Vaccinium Pennsylvanicum*), and while the *fruit of neither parent species is edible,* the fruit of the *newly created one is most delicious* and most abundantly produced, and the seedlings, generation after generation though produced by the million, still, all come as true to the new type as do either parent species to *their* normal type.

Still another example of this mode may be found in my experiments with opuntias. By crossing *O. tuna* with *O. vulgaris,* thousands of seedlings have been produced, all of which, in the first, second and third generations, though a well-balanced blend of the two natural species, still come as true to the newly created species as do either parent species to their own natural types.

Not only does this new mode hold true under cultivation but species are also summarily produced in a wild state by natural crossing.

The western blackcap (*Rubus occidentalis*) and the eastern red raspberry (*Rubus strigosus*) when growing contiguous, as they very commonly do in Central British America, often cross, forming an intermediate new species which sometimes sorely crowds both of the parent species, and when brought under cultivation still firmly maintains its intermediate characters, no matter how often reproduced from seed. And still further, our common "tarweed" (*Madia elegans*) with its beautiful large blossoms often crosses with *M. saliva* with its insignificant pale yellow flowers, producing a complete intermediate. I have not yet determined whether the intermediate will reproduce true from seed, but confidently expect it to do so. Similar results among wild evergreens and deciduous trees and shrubs and herbaceous plants have been frequently and forcefully brought to my attention, leaving little doubt in my own mind that the evolution of species is by more modes than some are inclined to admit.

HENRI POINCARÉ AND THE FRENCH ACADEMY[1]

By M. FRÉDÉRIC MASSON
PARIS ACADEMY OF SCIENCES

THE Académie Française is primarily a literary organization, and its special work is the preparation of a dictionary. But even in this enterprise it is desirable, as M. Masson points out in the document of which I propose to translate a part, to have expert assistance at hand in the matter of the meaning and use of scientific terms. It is probably for this reason that Henri Poincaré, already a member of thirty-five academies, was this year called to membership in the most celebrated of all academies.

The great mathematician entered the august body with a eulogy of his predecessor, the poet Sully-Prudhomme—which task was not as strange to him as might seem at first glance, since Sully-Prudhomme was educated for a scientist and all of his work shows a scientific turn—and was received, with the customary biographical welcome, by the historian Frédéric Masson. A study by a layman and for the ears of laymen, M. Masson's address is a thoroughly popular effort; but it has a great deal that is pleasing, and not a little that is suggestive. I quote, with considerable abbreviation, from the part which deals most directly with the new academician's life and work.

You were born, a little more than half a century ago, in that dear and glorious Lorraine which has furnished this body so many men remarkable in lines of activity so diverse; so soon after we have been cruelly touched by the death of Theuriet, of Gebhart and of Cardinal Mathieu, you appear, attesting, by the exercise of a totally different genius, the inexhaustible fecundity of your native province.

You come of an old race long established at Neufchâteau, and located at Nancy for a century. Of your name—*Pontcaré* (square bridge), rather than Poincaré (square point), for, as you have said, one might conceive a square bridge, but scarcely a square point—there have been magistrates, savants, lawyers, soldiers like the Commandant Poincaré, your great-uncle, whose tenderness for his wife and whose sad adventures M. Chuquet has narrated—like that other Poincaré, also an officer, who died for the republic in the year IX., whose son the first consul himself recommended to the ministry of war for a place in their offices, since, a corporal in the Seventh Hussars, "he had lost a leg and a thigh in one of the last battles which adorned the last campaign on the Rhine."

[1] Translated, with an introduction, by Professor Roy Temple House.

Your grandfather was a pharmacist; it was at Nancy, in his house, opposite the ducal palace, that you came into the world; and this house, solid, massive and without ornament, is entered through an almost monumental portal whose worm-eaten posts support a broken pediment bearing the semblance of a boiling pot. Some found a bit of symbolism: the portal is poetry; the house is prose; it gives an impression of bourgeois simplicity and of settled living which is by no means trivial. Your father, a physician, was a conscientious student, a distinguished practitioner; and the faculty of Nancy, where he took his course, considered him a master of whom they were justly proud, at the same time that the working population saluted in him their benefactor. He was one of those men who, having been led by a noble curiosity into the most emotional and uncertain of professions, practise it with admirable disinterestedness and hold themselves amply repaid if they are so fortunate as to save a human life now and then. For the honor of the nation, there are many of the sort in France; but few have been able, like Dr. Poincaré, to discharge the duties of so absorbing a profession, to work in the laboratory, to teach assiduously, and at the same time to travel extensively over Europe.

Your mother was one of those alert, active women, always in motion and always busy, whose spirit of order, organization and command rules a household. She also was a native of Lorraine, of an old local family, home-loving, attached and riveted to the soil; the boys, no matter how brilliantly they had begun life, were never easy till they had returned to the home-nest to live, hunting on their estates or supervising their cultivation; two of your great-uncles joined to their rural tastes an inclination for geometry. Your mother wasted no time on such matters, finding enough to busy her in those occupations which are duties, and which, cheerfully accepted as such, become pleasures. Ah! what admirable sources of vital energy are these Frenchwomen, honest and shrewd, economical and judicious, sovereign in their own domain and disdainful of the other conquests, constantly busy at reforming the national virtue and transmitting intelligent patriotism to their children! . . . In your home you found an uncle recently graduated from the École Polytechnique. What a prestige surrounds these young men who, by a mental effort which is sometimes excessive, succeed in obtaining the first places in their generation, and to how many mistaken choices of vocation does their example lead! But with you, sir, the vocation had nothing to do with example; you were predestined to mathematics! This aptitude, in your paternal and maternal family, is transmitted in collateral lines like the throne in the House of Osman, and yourself twice heir of avuncular gifts, I am told that you have selected one of your own nephews for the precious succession.

You did not wait long to reveal your vocation, and you are justly

cited as the most precocious of infant prodigies. You were nine months old when you first saw the sky at night. You saw a star come out. You obstinately pointed out the shining spot to your mother, who was also your nurse. You discovered a second, with the same astonishment. You greeted the third, the fourth, with the same cry of joy and the same enthusiasm; it was necessary to put you to bed, you were so excited by your new occupation of star-finding. That evening brought your first contact with infinity and your first lesson in astronomy; you were the youngest professor known.

I have been told that you were a delicate, alert, charming child, spoiled and adored by your parents; a terrible illness suffered at the age of five years, as a result of which it was feared that you would never be able to speak again, left you more delicate, timid and somewhat awkward, so that you were afraid of the noisy games of the boys and preferred the society of your little sister. I do not imagine that violent sports ever tempted you, or that you ever became skilful in them. Nevertheless, you learned to hunt very large game. As soon as you learned to read, your curiosity was excited by those books of popular science which have replaced fairy stories in realistic schemes of education. You found extreme pleasure in them, and you experienced a grandiose horror in witnessing cosmic upheavals and battling with antediluvian animals. It was formerly the fashion to run after Prince Charming and awaken Sleeping Beauties. Now the child is no longer expected to make the acquaintance of those trivial personages; he must content himself with those whose skeletons have been discovered. Let me ask you: Between creatures which have really lived and of which we know nothing and never shall know anything, except that they lived, and beings which have lived only in the dreams of humanity, but which in the course of the ages have gratified us with so much beauty, grace and poetry, which are the more real, which bring more of light, of consolation, of joy? But you were not made to sit in the arm-chair of Charles Perrault.

It was in your father's house that you received from a retired teacher, a friend of your family, your first notions of things; he did not require written exercises from you; he conversed with you, talking of everything at haphazard; this encyclopedic instruction was so appropriate to your nature that when you entered the *collège* you at once took the first place; but this sort of work would be injurious to children of different endowment. Your memory was and still is more auditory than visual. Pronounced words engrave themselves on it. When you come back from a journey, no matter how long, you can recite the names of all the stations you have passed, if you heard them cried before your car. More than this—a character presents itself to your mind like a sound. In the evening, you can recite the numbers of

all the coaches you have met in the course of the day, but you hear them, you do not see the figures. This is one of the most remarkable peculiarities of your brain, and I venture to note it because I have the unanimous testimony for it of those who know you most intimately.

At the *lycée* of Nancy, you were superior to your comrades in every branch, and you seemed so well endowed for literary studies that one of your teachers, who is one of our best historians, would have been glad to attract you to our speciality; but when, in the fourth grade, you opened a text on geometry, the work was done. Your astonished teacher rushed to your mother and said to her: "Madam, your son will be a mathematician." And she was not particularly frightened. Mathematics, as soon as you made her acquaintance, seized you and held you. She is a tenacious mistress, with this peculiarity, that she fires all her lovers with the same impulse: the mathematician is a peripatetic. Pedestrian exercise seems necessary to him in order to stimulate thought, and, as he walks, certain mechanical gestures with which he occupies his fingers seem the indispensable auxiliaries of an intellectual labor that leaves him indifferent to the exterior world and even unconscious of it. One day, when promenading, you suddenly discovered that you were carrying in your hand a wicker cage. You were prodigiously surprised. When, where, how had your hand plucked this cage, which was new and fortunately empty? You had no idea, and retracing your steps, you walked until you found on the sidewalk the stock of a basket-maker whom you had innocently despoiled. Such phenomena are very common with you; they will become, if they are not already so, as celebrated as those attributed to Lagrange, to Kant, to Ampère. You might be in worse company.

You were, nevertheless, at times, a child who liked pleasure and games, but you invented your own amusements. You played at railroad or *diligence* with a map or a guide in reach, and thus you learned geography. You put history into dramas and comedies; at sixteen years you had written a five-act tragedy in verse, and you would not have been a son of Lorraine if the heroine had not been Joan of Arc. Even charades had a charm for you. Are they not problems?

The war interrupted these games. You were sixteen years old; your age and your health prevented your mingling with the combatants, but you tried to make yourself useful; every day you accompanied your father to the hospital and served as his secretary; you were so eager to learn the news that, in order to read them in the only papers that were accessible to you, you learned German. The war must have matured you; it certainly left its trace upon you; but it did not change your life. To the men of the generation preceding yours, it brought a definite conversion with introspection. You have read Sully-Prudhomme's verses entitled "Repentance." In them he confesses the error into which the generosity of his heart had drawn him and in which the fal-

lacious discourses of the rhetoricians had maintained him; in order to carry out designs which were unworthy and shameful, these gentry resort to sonorous words to lull a careless people to security; and when the nation awakens and finds herself rolling into the abyss, she cries out treason but is unable to distinguish the traitors. So Sully-Prudhomme had detested war and shown himself rather disdainful of soldiers. Then he learned from his own experience that any one who chooses can not be a soldier, that it is one thing to deliver philosophic harangues and another to submit one's physical and moral being to monotonous regulations and entire self-effacement; he learned—and the lesson cost him dear—that in order to possess the right to think, one must have conquered first the right to live; that it is folly which would be ridiculous if it did not bring such despair to profess humanitarianism when all of Europe is under arms; and that, however inelegant the solution may appear, there is but one, if a people intends to maintain its nationality, guard its independence, continue its race, possess its territory, speak its language—and the solution is to be strong enough to defend them.

You lived your life, sir, under the yoke of the victorious enemy. It was in a city occupied by the Germans that you resumed and continued your studies. You were thoroughly successful in them; but the joy was doubled for you by the fact that your public success coincided with the evacuation of Nancy. As our dear late colleague Émile Gebhart has told us, it was in a hall filled with the joy of deliverance that you received your last scholastic honors. You held the first rank, a native of the city and ten times a prize-winner. You carried off the prize in mathematics from all your rivals, from Paris and the departments; it depended on you alone to enter the School of Forestry second on the list of appointees; this would have been another glory for Nancy, but you refused to go further with the school than to leave your visiting-card; you were distrustful of the fallacious dryads who delight in troubling the absent-minded.

The next year you presented yourself as a candidate at the École Polytechnique and at the same time at the École Normale; for the latter you stood number five, for the former number one. Which of the two great schools would you choose? That which decided your choice, more even than the familiar memories, than the temptation of the uniform and the glory of the sergeant-major's chevrons, was it not, tell us, the groaning of the mutilated fatherland? But you never reached the point of entering upon a military career. Your scientific bent showed itself so brilliantly at the school that there was no question of another sort of glory; your residence there is a matter of piously transmitted tradition. It is related that you attended your classes, at least in mathematics, without taking a note, without reading or even collecting the mimeographed sheets which reproduce the professor's lecture. Your method

was to classify the results established, to study their connections, with no care for the demonstrations, sure of finding others, if you happened to forget the ones which they had employed; at the time of your entrance examination, did you not find a new solution for a problem which had been set you? When you worked, you did not remain in your room, but gave your brain a promenade through the corridors, and in place of a pen, a pencil or a piece of chalk, your hand was busy with a bunch of keys—your opener of ideas.

Your superiority in mathematics was so decided that, in spite of your inaptitude for anything practical—manipulations, linear design, imitative design—you were, at the closing examination, placed second, and admitted to the School of Mines. There you found life pleasant for more than one reason. In the first place, in the Latin Quarter, you lodged with one of your cousins, who was taking a literary and law course. . . . With him, in the practise of peripatetism—which was, perhaps, less a philosophical school than a physical peculiarity of philosophers and mathematicians—you followed those studious rounds in the course of which you discussed philosophic themes, already indissolubly associated in your mind, as in those of the ancients, with mathematical theories.

In 1880, the Academy of Sciences had set as the subject of the mathematical great prize, the theory of differential equations. When the illustrious M. Hermite presented his report, he mentioned a discussion bearing the motto: *Non inultus premor,* whose anonymous author he invited to persevere in a work which promised to produce results. The motto was that of Nancy; you were the author; but your paper was only a first sketch; you presented at that time only the results which you were soon to obtain and which, in the month of February, 1881, burst forth—it is the only exact phrase, says one of your admirers—in the report of the Academy of Sciences. From week to week, with the notes which you sent out regularly, your discovery increased in precision and amplitude for a period of nearly two years. Your contribution was the "the crowning of the work of Cauchy and Riemann, the representation of the coordinates of any algebraic curve in uniform functions, the integration of linear differential equations with algebraic coefficients—it was a new and immense perspective opened to view."

This discovery was a great victory for French science. For some years the German geometers had been roving about the house without finding the door. You located it and opened it.

From there I need not follow you in your career: Professor in the University of Paris and the Ecole Polytechnique, your lessons have had an unequaled vogue; and if, among your auditors, many were not able to follow you, all agreed in proclaiming your astonishing superiority; at thirty-two years you were elected a member of the Academy of

Sciences, you have been called into the majority of the scientific societies of two hemispheres; you have received all the honors that a legitimate ambition could crave. Your name, going out beyond the narrow circle where your work can be appreciated, has become illustrious and added to a nation's glory, and this fame you owe only to yourself; it is the gift of no one, you have followed no master, you belong to no school, you are yourself—and that is enough.

Similarly, when you undertake a criticism of science, you make it a personal matter, and without adopting any tradition, without bowing to any formula, you walk on in your independence and because you choose to. You run indeed, and so fast, with such bounds, that in order to follow you it is necessary to leap ditches and fill in gaps; but you are built so. Original in mathematics, you remain so in this branch of philosophy; you apply to it, at the same time, a highly-developed interest in psychology, a rare aptitude for observing physiological phenomena in your own person, and that mathematical habit which organizes precision and with refined subtlety binds arguments together with chains that seem impossible to break. Restrained by nothing which you place confidence in or accept *a priori,* you build up your doubt against official science and sound its nothingness. So your work is double: in mathematics you erect to scientific truth a temple accessible only to the few initiates; and with your philosophic artillery you hurl into the air the chapels about which throng the crowds of rationalists and free-thinkers who by a common school certificate have acquired the right to believe in nothing which is not proved to them, to celebrate the mysteries of a pretended religion of science. Ah, sir, what havoc you are making in these demonstrations! Nothing would survive the rudeness of the blows you are dealing if you did not stop from time to time to banter your victims, or if, seized with a sort of remorse, you did not amuse yourself by gluing together again the members you have broken. The axioms which seemed established by the wisdom of the ages are no longer more than definitions when you have passed; the laws become hypotheses; and at the same time that you prove the essential rôle of these hypotheses, you show their merely temporary utility—you make it evident that these definitions are convenient but ephemeral. What remains? Nothing, or little more than nothing, and the most precious idols of primary religion go to join the dead stars in the depopulated heavens.

Does this mean, sir, that you doubt science more than truth? Neither the one nor the other; but the latter gives way constantly before the advance of the former, and, as man proceeds one step farther, the space he must cross withdraws before him; beyond the steppe whose extent his eye embraces, others await him, and still others, for he only is assured of reaching the end who stopped with the rudiments—and learned them by heart. . . .

COLLECTING AND CAMPING AFOOT

By A. S. HITCHCOCK

SYSTEMATIC AGROSTOLOGIST, U. S. DEPARTMENT OF AGRICULTURE

EVERY naturalist wishes to spend a part of his time in the field, observing, taking notes and making collections. It often happens that such field work can be done best by camping. Methods employed by field naturalists while camping vary according to the character of the country and according to the objects to be attained.

It is the purpose here to give a few hints concerning traveling on foot, and carrying a light camp outfit on the back as a pack. These hints are based upon considerable experience with this method of camping in various parts of the United States, and are given with the hope that others may find them an aid in planning similar trips. This kind of camping can be of service only when the necessary collecting outfit and specimens collected are comparatively light in weight and when the area of the region to be covered is considerable. In my own work I can use this method because I am collecting only grasses which are easily prepared, and because I wish to cover in a single season a wide area, usually several states. I wish to travel quickly by railroad or other regular transportation, from one locality to another, often two or three hundred miles apart, spending one to five days in each place. It does not pay to outfit with wagon or pack animals for so short a time and one is not sufficiently mobile when stopping at hotels. With a light outfit one can start into the field as soon as he arrives at a station, thus saving much time. If more than five days is required for a given excursion, I am in the habit of taking a pack animal to carry my outfit, as I can not conveniently carry in a pack provisions for more than that number of days.

In calculating the details of an outfit one must first determine the weight he is able or willing to carry. If the weight carried is too great the mobility is too much reduced. Yet enough in the way of food, clothing and bedding must be carried to prevent too much risk to the health from short rations and exposure. The problem before us is to adjust the factors so that the result may represent a maximum efficiency. I endeavor to keep the total weight of my outfit within fifty pounds and we may assume in general that a man should limit his pack to a third of his own weight. With this weight I count on walking fifteen to twenty miles a day over ordinary roads or trails that do

not include over two thousand feet of total climbing. In climbing one can count on one thousand feet an hour, without a pack if the trail is steep. With a fifty-pound pack the time is about doubled. If one finds it necessary to carry more than the weight indicated, the distance traveled is correspondingly reduced. From the total weight one must subtract the weight of the collecting outfit. My own outfit consists of a wood slat press with straps, twenty-five light-weight driers, one hundred sheets of inner papers, a few ounces of cardboard slips for fastening over the bends in specimens, and my plant digger. The total weight is not over five pounds. The weight of the specimens gathered is not likely to be, on a single trip, more than five pounds, which increase in weight is, however, offset by the decrease in weight of supplies. We have then forty-five pounds for the remainder of the pack.

The outfit may be considered conveniently under the following heads: clothing, bedding, cooking utensils, provisions, miscellaneous. The exact selection depends upon the length of the trip, the character of the country, climate, accessibility of supply stations and many other conditions which can not here be foreseen. It is clear that in the high Sierras more bedding is necessary than in Florida, that more provisions must be carried in a wilderness than in a settled country, and that rain or mosquitoes must be provided against where these occur. Therefore in discussing the requisites for an outfit I shall not make a definite selection, but shall offer suggestions as to such selection based upon my own experience.

In my own work I travel from place to place with the usual baggage allowance of one hundred and fifty pounds aside from my hand baggage. In this baggage I carry such articles as I am likely to need at hotels where I may stop, and also a selection of camp equipment, and extra driers and other collecting supplies. Sometimes I go first to a hotel, where I leave my baggage while I make an excursion of a few days on foot. Sometimes I travel in camp clothes and pack, in which case I can leave my baggage at the depot and go at once into the country.

Concerning clothes for camping, I can say little except that it is very necessary that the foot covering, whatever its other qualities, should be well fitted and well "broken in," for it is absolutely essential in a walking trip that the feet should be kept in good condition. As to other articles, I prefer heavy socks, wide-brimmed cowboy hat, and, in the mountains, woolen underwear. I usually go without a coat, but carry a sweater. The extra clothes may be reduced to an extra suit of underwear, an extra pair of socks, two large handkerchiefs and a pair of moccasins. The latter I use chiefly at night.

The bedding may be reduced to a single blanket of moderate weight or two of light weight. I also carry a waterproof poncho. This is a protection against rain, dew or damp ground at night and can be used

as a cape in the daytime in case of showers. I carry in my baggage a light, so-called balloon silk A tent for use in regions where one may expect rain at night. This has a ridge rope by which it is suspended and weighs six pounds. In mountain regions where the nights are cold I depend for warmth on keeping a fire during the night, rather than on carrying extra bedding. But in my baggage I carry a waterproof sleeping bag for use on longer trips with a pack animal. Where mosquitoes abound one must be provided with a cheese-cloth tent, or at least with a head veil.

The cooking utensils may be reduced to a very few pieces, but in this aluminum age one may add a few luxuries. While one can with patience cook over a small fire between stones, this method has its disadvantages. There may be no stones; but even when these are present it is not easy to find them of the proper size and shape for the small vessels used by one person, such as a pail four inches in diameter. I therefore usually carry a "stove" or grate. This consists of three pieces of strap iron about fifteen inches long, fastened by four cross strips. This can be set across stones or small logs and is certainly a great convenience. It is strong enough to hold in the middle a quart of water. When packed it is placed in a cloth sack to prevent the soot from soiling other articles. Two or three dishes may be cooking at the same time by this means. The cooking utensils consist of a straight-sided coffee pot, a pail in which this fits, both of aluminum, all with the parts riveted, not soldered, and finally a small frying pan of iron. I have not found aluminum so satisfactory for the latter article, as foods cooked in it seem to burn more easily. A second small pail is a convenience, in fact I often use in an emergency a tin fruit can with the top melted off and a wire bail attached. Each utensil used over the fire should be packed in a light cloth bag to prevent the soot from soiling the other articles. One can not take time to remove soot after each meal. In addition might be mentioned a plate and two bowls of aluminum, a drinking cup of tin (aluminum gets too hot), knife, fork and dessert spoon. I must not fail to mention the canvas bucket. This is light and collapsible, and is very convenient to bring a supply of water from a distance. One can not always camp in the immediate vicinity of water. The best matches are the old-fashioned sulphur kind that come in blocks. These should be kept in a waterproof box. In a recent work on camping I saw mentioned a handy contrivance for blowing the fire. It consists merely of a rubber tube with a short metal tube at the end. When cooking with such a small outfit it is necessary to use a small fire, frequently replenished. The blower serves a useful purpose for bringing the fire quickly into action. I have used this article during the last season and can heartily recommend it to others. In describing my outfit I mentioned a plant digger. For this purpose

I use an "intrenching tool," an implement in use in the army. This is a broad-bladed knife of good steel which fits in a scabbard carried at the belt. It is an excellent thing with which to dig plants, but it can be used for several other purposes, the most important of which is to cut fire-wood and incidentally to make friends with vicious dogs. This tool may be obtained of Francis Bannerman, 549 Broadway, New York.

In choosing the food for such a trip as described one is limited by the available supply and is governed by one's tastes and by the necessity of reducing the total weight to a minimum. It is essential that the ration be fairly well balanced. The following is given only as a suggestion, as tastes and conditions are so variable. It is also to be remembered that the supplies must be obtained from ordinary sources as found in the region visited. A few kinds of food, such as erbswurst and dried egg, I may provide at the beginning of the trip, as these can not be purchased at village grocery stores. For drinking I carry cocoa, as coffee is more bulky and tea I do not care for. If cold water of good quality can be obtained I drink the cocoa only at breakfast. To the cocoa I often add a little arrowroot. To avoid lumps the sugar may be mixed with the dry cocoa before the hot water is added. Milk I carry in condensed form. Dried milk is not so satisfactory, as it does not mix well for cooking, but it has the advantage of light weight. Since a can of condensed milk will last one or two days, according to size, it is necessary to protect an opened can or there will be a fine mess in one's baggage. I keep the can in a closed tin can just large enough to hold it. The milk can is opened by driving two small wire nails in the top at opposite sides. When not in use the nails remain in as stoppers. The foods may be classified into carbohydrates, fats, nitrogenous foods, fruits and condiments. Of the first may be mentioned sugar, which with me is an important article of diet, as I eat half a pound a day. The starchy foods present considerable variety. Bread heads the list, but not infrequently one is unable to obtain this at a supply station. Furthermore, on a walking trip one can scarcely count on carrying bread sufficient for more than two days. Flour is likely to be the staple. I have found self-rising pancake flour the most convenient, as this comes in small packages all ready for use. One can carry but a few pounds of flour and it is difficult to obtain so small a quantity of the ordinary sort at a store. Other starchy foods that I often use are grape nuts, cream of wheat (or similar breakfast food) and rice. This last, however, I do not much relish, though it is improved by cooking with raisins or dried fruit. When possible I add potatoes and onions, but both are bulky and can be carried only in small quantity. The fats are supplied usually by bacon. Butter can be carried only in the mountains where the climate is cool, otherwise it turns to oil. The nitrogen may be supplied by canned meats, which are heavy; by canned beans,

which are also heavy; by dry beans, which take too long to cook to suit me, or by dried egg. I depend largely upon this last. It comes in convenient-sized cans and has proved very satisfactory. One can make omelette or scrambled eggs, or it can be mixed with the flour for cakes. I use the last method frequently, putting into the flour the equivalent of two eggs. Fruit is an essential in camping. I prefer dried cherries, but if these can not be obtained, I use prunes, dried peaches, apples or whatever is available. A package of raisins is a good thing to have. Of the condiments I carry only salt, as I do not care for pepper, vinegar and so on, which are inconvenient and superfluous articles for a pack. There are various kinds of concentrated soup packages on the market only one of which I have found worth carrying. That is erbswurst, sold by Abercrombie & Fitch Co., of New York. It is put up in pound, half-pound and quarter-pound packages and consists of a meal ground from peas, vegetables and meat, seasoned, ready for use by adding water. It is a balanced ration easy to prepare and very concentrated. On a forced march one could subsist upon this alone.

The miscellaneous portion of the outfit includes a few toilet articles, a pocket dissecting outfit, together with bandages, carbolated vaseline, etc., for patching myself in case of accident, needle, thread, twine, safety-pins and similar small articles. For packing these and the food not contained in the original cases I use small cloth bags. The sugar, dried fruit, rice or even the flour or cream of wheat, is transferred to a cloth sack, as paper sack or pasteboard boxes will not withstand close packing.

The greater part of the outfit is carried in a pack upon the back. If the bulk is small an ordinary soldier's knapsack is satisfactory. When it is necessary to carry more the outfit may be placed in two waterproof duffle bags and these carried in a strap pack. The most satisfactory pack that I have tried is the Merriam pack by which a portion of the weight is supported at the hips.

In a trip of three to five days from a station, the outfit consists, then, of the Merriam pack in which is placed every thing except the poncho and blanket which are folded in a roll on the outside, the plant digger carried at the belt and the plant press carried in the hand. I carry in addition a haversack for overflow articles. I try to start with two loaves of bread, which being too bulky for the pack I place in the haversack. In this I carry also my note book and drinking cup.

Having decided upon a route for a short trip, which should be arranged if possible so that no portion is traveled over twice, I carry my pack to a favorable locality for collecting and unload. After exhausting the collecting I move on to another place. Occasional plants are dug up without removing the pack but this is somewhat of a strain and should not be done regularly. One is obliged to rest every two or three

miles, and by selecting the proper localities, these halts can be used for collecting. The pack can be removed by unfastening a single clasp. If long side trips are to be made, such as climbing a mountain, the outfit can be cached until the return.

An average day in the field, thus equipped, would be about as follows: Supposing that I have arrived in the forenoon at the terminus of a branch railway line in the mountains, I obtain such supplies as may be necessary and start at once toward what appears to be the most favorable collecting ground. At noon I eat a light lunch such as grape-nuts, usually not going to the trouble of making a fire. About five o'clock in the afternoon I begin to watch for a favorable camping spot. The requisites are good water, firewood in abundance and a comfortable location for my camp. As I carry no axe it is necessary that the firewood be in shape for use without chopping. At altitudes where the temperature sinks to 40° F., it is necessary to keep a fire all night, as the bedding carried is not sufficient to keep one comfortably warm. A level spot is selected and freed from stones, sticks and cones. It is an advantage if one can place his bed by a large rock or log and build the fire a short distance in front as the heat is then reflected and the wind is kept off. It is scarcely safe to build a fire against a large log or stump, as it may start a forest fire or it may at least be troublesome to put out the next morning. A supply of firewood should be placed near at hand and the fire replenished as needed, which is at intervals of about two hours during the night. There is no advantage in making a larger fire as one is driven farther away and gets cold just as soon when the fire dies out, and furthermore there is more danger from sparks falling on the blanket. It may be remarked that the falling temperature always wakes one up in time to replenish the fire if the nights are cold. Having gathered the firewood one prepares for supper. I do not utilize the large fire for cooking, but build a small fire near-by, under the grate previously described. The small fire can be controlled to suit the requirements. As one sits near the stove while cooking, the fire must not be too large. The supper is with me the important meal of the day. There is time to cook such articles as need prolonged boiling. At this meal I have pancakes, bacon, potatoes, onions, fruit or whatever my supplies will furnish. As the cooking utensils are limited to a frying pan, coffee pot, pail and tin can, the amount of cooking that can be carried on at one time is limited. Enough dried fruit is made into sauce to last for the breakfast and possibly the lunch following. Cream of wheat will also be cooked for the following breakfast. If potatoes are carried enough are boiled at night to give a small surplus for frying the next morning. As a matter of fact when one is alone it is necessary to limit the variety of food at any one meal, since it is not convenient to carry in a pack the surplus from a meal, especially if in liquid form.

Supper over I go to bed at once. The bed consists of the poncho and blanket doubled on the ground near the fire. I never take the trouble to collect boughs or otherwise prepare a bed, except to remove obstructions. If soft turf is present so much the better, but this does not often happen. Usually I sleep on the bare ground as bunch grass is not comfortable. As explained before I carry an extra suit of underwear and a pair of socks. At night I remove the clothes worn during the day, put on dry underwear and socks, and if the weather demands, put on the other suit of underwear over the first, and finally the sweater and moccasins, and am ready to fold myself in my blanket. To do this I spread the blanket and poncho over me, roll first to one side, then to the other until the slack is taken up on each side. In this way the two edges are lapped beneath and I can roll to either side, the blanket remaining tight. For a pillow I use the bag in which I carry my clothes, filling it with leaves. I arise at dawn and retire soon after dark, for there is little to do when alone by a campfire.

As partially indicated above the breakfast consists of cocoa and cream of wheat or other breakfast food cooked the night before, and if I am hungry enough, other food left from supper. The utensils are now cleaned and packed for the day.

The plant driers are changed once or twice a day. As I usually carry only twenty-five driers, it is necessary to remove the plants and dry the driers in the sun, or if the weather is damp, before a campfire. Ordinarily in sunny weather I attend to the drying about 10 A.M. and 2 P.M., most grasses being dry in twenty-four hours. In this way I can prepare about twenty-five specimens each day. But if the collecting is particularly good I can double the number by drying before the campfire at night.

With the outfit I have described one can travel safely, that is, without subjecting himself to exposure, but the work is not easy. Of course if two persons arrange to travel in company the trip would be more pleasant and a few additional comforts might be included. One advantage in traveling afoot is the mobility. Little time is lost in getting to the collecting ground and one is not confined to roads or trails as when traveling with pack animals. One can cross a mountain range or from one railroad to another. The available range with full complement of supplies is as much as one hundred miles.

The traveler should be provided with good maps and a compass. Topographic sheets of a considerable portion of the country can be purchased from the United States Geological Survey.

The above suggestions are offered for the purpose of aiding any who propose making natural history collections. I should not advise this method for those who are going for pleasure only, as it is hard work and the necessary drudgery is only balanced by the increased opportunity for collecting and observing.

THE NECESSITY FOR AN INTERNATIONAL LANGUAGE

By IVY KELLERMAN, Ph.D.
CHICAGO

IT was urged by a certain Greek philosopher that in ignorance alone lay the real reason of wrong-doing, and that none who truly understood the right could thereafter be guilty of wrong. Ignorance in a narrower sense has been offered as the explanation for misunderstanding and consequent trouble of a more or less serious nature between nations and races as well as between individuals. Ignorance of one another's civilization, lack of appreciation of each other's character and ideals, failure to comprehend the motives of essentially simple actions —all these are at fault when great nations disagree. No other interpretation is indeed possible, since longing for power, love of conquest, lust to slay, can hardly be suggested in calm seriousness as motivating the actions of nations who are followers of the gentle Jesus, the kindly Buddha, the wise Confucius, in a supposedly civilized century.

It seems strange at first that there should be room for such lack of mutual understanding and sympathy, in view of the vaunted increase of international intercourse, due to the many opportunities of communication by mail and by wire, to the great interchange of commodities made possible by commercial progress, and to the growing facilities for international travel. It seems strange, also, when we recollect that in the employ of every nation there are numerous persons skilled in the language of every other nation of political or commercial importance, to serve the one as interpreters of the thoughts and words of the other, and to translate the ideas and ideals of these peoples for each other in any emergency that may arise. Such experts are found likewise in all great educational centers. There is not a university without its corps of trained linguists, while its leaders in all of the various departments must possess a fair degree of familiarity with numerous foreign tongues. Even the students are becoming slightly cosmopolitan. A few Americans and Englishmen and Orientals are found at every European university of note, while in America are scattered students from Europe, from the far east and from South America.

Therefore we may claim to have interpreters. They are few indeed, in proportion to the number needed, as has been forcibly pointed out, with the plea that "governments, universities, churches, chambers of commerce, should have some definite plan of raising up a body of sympathetic scholars, who shall be first-hand interpreters of one nation to the other."[1]

But in this very claim lies the explanation of the puzzle. As long

[1] Document 15 of the American Association for International Conciliation: "American Ignorance of Oriental Languages," by J. H. DeForest, D.D., page 12.

as interpreters are needed, as long as the ability to interpret rests only with the officials of the government, the faculties of the universities, and the small proportion of citizens and students who have opportunity of extended residence in at least one country besides the native one, just so long is perfect understanding impossible. For perfect understanding between two nations results from an understanding between a majority of the citizens of these two nations, not from even the most perfect understanding and appreciation of one by but a small minority in the other. This is true even if the minority happens to be the political body in control. For in one way or another the people rule, and public opinion and desire, however faulty, exert a mighty influence.

Accordingly, if international sympathy and agreement rest upon adequate mutual understanding attained through the complete comprehension of more languages than the mother-tongue among the general public—whether these languages be spoken, printed in newspapers, pamphlets and books, or written in letters amicably exchanged—the immediate solution suggesting itself is this: Let all or a majority of the citizens of each nation learn thoroughly the language of each other nation. Then will the barrier to intercommunication disappear. Each individual may read at will and at once the publications of every other; may express his ideas and have his questions answered, orally or by correspondence, with citizens of any nation; and may feel himself linguistically at home in any country of the world, without the present need of guidebooks, couriers and interpreters, ever provocative of mutual distrust.

Such a proposition is, however, utterly futile from a practical point of view. Persons in comfortable financial circumstances may learn several languages besides their own, business men stationed in foreign countries may do so to some extent, and peasant immigrants may do the same in limited degree; but the possessor of more than a moderate familiarity with two or three languages is called a linguist, and placed in a class apart, as differing by that very fact from the majority of mankind. Genuine admiration is accorded any person who has completely mastered three or four languages in addition to his mother-tongue, and speaks and writes all of them with equal fluency, exactness and elegance. Nor is any one surprised to hear that such an expert spends many years and much care in acquiring these three or four languages with a reasonable perfection of pronunciation, syntax and style, or that teaching this is in itself a profession worthy of remuneration.

Yet to be truly a polyglot one must be familiar with not only French and German, English, Spanish, Italian, Russian, each difficult of mastery, and the Scandinavian languages, but also Dutch, Flemish, Portuguese, Roumanian, Catalonian, Greek and the many languages allied to Russian, such as Bohemian, Polish, Servian, Bulgarian, Lithuanian, etc., and also the non-Aryan tongues of Europe, such as Hungarian and

Finnish and the scattered Yiddish. Not even with this may he be content, although it demand the work of a lifetime and more, but must turn to the east, with its Persian, Armenian, Arabic, Turkish and numerous Hindoo tongues, and then pass on to China and Japan, and even to Korea.

Who can boast of all this? Yet who will deny that not one nor many, but in truth each and every one, of the intelligent citizens of every nation should have the power of overcoming these linguistic barriers? This is one of the great needs of the civilized world, as urged in the Prime Minister's address at the Seventeenth Universal Peace Congress held in London, July, 1908: "I have said it before, but I would say it again, *the main thing is that nations should get to know and understand one another.*" This is profoundly true. Not only the future but the present of these various-tongued races and nations is intertwined to such an extent that the power of free intercommunication is an imperious necessity. But if this direly needed intercourse is so impossible of universal or even fairly general attainment under existing circumstances, another solution must be sought.

The solution that presents itself next is, that some one of these languages be chosen for universal international use. Next after the mother-tongue, this should be learned by every inhabitant of the civilized world, and all publications of any importance whatever should be published directly or in duplicate in this international medium. All international correspondence should be thus conducted, and the language likewise used in all international assemblies and conventions. To learn one language besides the native tongue would not be so absolutely impossible as the absurd idea of learning many or all of them. The proposal is good, and the selection of this language at once becomes a problem worthy of attention, for that one language should serve all nations of the world in international dealings is eminently reasonable.

The place of a semi-common language among the educated classes was held by Latin in the middle ages, and the mind at once reverts to this, with speculations as to the possibility of its revival. But Latin can not serve this purpose. Its vocabulary is too limited and too unsuitable for discussion of modern themes, since even a bicycle or an umbrella demands circumlocution in Latin, while the introduction of new and modern words would destroy its purity, and make it but a barbarous hodge-podge of Latin forms. Moreover, the difficulties of Latin grammar and syntax prevent this language from being easily mastered. Only at the expense of much time and effort can the modern mind completely assimilate the ancient ways of word-inflection and sentence construction. Any one may admire the purity and severe elegance of Ciceronian Latin, but not every one is able to imitate it. Yet Ciceronian Latin would unhesitatingly be chosen as the standard for a revivification of this tongue. The silver Latinity and that of the

middle ages are as out of the question as the "modern" Latin which for want of a better medium is forced to serve in a multitude of scientific classifications and descriptions of the present day. This too is in regard to Latin as a written language. Speaking it is a still more difficult problem, one before which even the Latin specialist is ill at ease. It is evident that the idea of bringing Latin in any shape into real use as an auxiliary language in the busy modern world is absolutely hopeless.

What is true of Latin is equally true of Greek, with its own peculiar alphabet, used by no other language, and its even greater remoteness from present European tongues, in spite of the many derivatives from it in modern vocabularies, especially in technical terminology, and in spite of the fact that the idiom developed from ancient Greek is a spoken language to-day. The languages of the past can not serve the peoples of the present in any immediate and practical capacity.

The next alternative is the consideration of the modern and living languages. For French was the accepted language of European courts, in times not yet remote, as well as the language of diplomacy and of polite literature; although, as in the case of Latin, this language too was semi-universal among chiefly the educated and politically powerful classes. Is it feasible to restore French to that high estate from which it has now fallen? Hardly so, with English a powerful competitor, and German vying with both. From this very competition it is clear that neither French nor any other national speech can to-day or to-morrow become the accepted auxiliary language. This idea, untenable now, may find acceptance in the far future, *after* the establishment of international unity and understanding, and after the forgetting of international jealousies and struggles for political preferment and commercial supremacy. But at present it is plainly Utopian. No nation of to-day will yield to any one other nation the immense commercial and political advantage given by permitting the mother-tongue of that nation to become the accepted medium for international dealings. No American or Englishman would consent to an attempt to have German used exclusively, in his intercourse with Spanish-speaking peoples, or any other peoples, nor would he consent to French for such a sole medium. No German would accept French in this capacity, or English; nor would the Frenchman be a whit more generous. This same feeling, intermingled with a host of ancient grudges, would extend to the lesser nations whose languages meet with still less consideration in such theorizing.

In days of old, that nation politically most powerful might sometimes thrust its language upon conquered peoples, by sheer force of arms. This method is rather impracticable to-day, although a hint of it remains in the ineffectual struggles of the Poles to retain their own idiom in spite of the "official" tongues established among them, or of the Boers against the "official" English. Clinging to the native

tongue overbalances practical and economic considerations, and hence the Flemish, Celtic and similar "revivals."

The proportion of those speaking a certain language is no less impracticable a basis for the choice of an international auxiliary medium. Leaving out the question of Asiatic tongues, in spite of their superiority in this regard, the selection is among those same reciprocally jealous nations, namely, Russian, French, English and German. Moreover, this method would be unfair to multitudes among nations speaking other languages. For even French (in France, Belgium and Switzerland) is spoken by only about forty-five millions among the three hundred and fifty millions of Europeans, English by about forty millions, and so on. If the calculation be made upon a wider basis, and the new world and the far east included, the additional figure for English would be more than neutralized by the additional figure for Spanish tongues and the entrance of the multitudinous non-Aryan as well as Aryan languages.

Let still a different basis for the selection be offered: Let that language be chosen which is the easiest of acquirement for all peoples to whom some other language than this is the native tongue. This is even more perplexing. The people of each nation, accustomed to the national language from infancy, are unconscious of its peculiarities and irregularities, its difficulties of pronunciation, inflection and syntax, and its various idiomatic expressions. Not aware that these are difficulties, they unhesitatingly declare their own language the easiest of all. Yet English-speaking people would debar German from the choice because its mastery takes far too long, and is woefully hampered by the umlaut vowels, the three categories of grammatical gender, the complicated verb and the troublesome word-order. Similar objections exist for the Scandinavian languages, while against Russian are its additional vowels and additional consonant combinations, its perfective verbs, its seven-case substantive, with changing declensions for noun, adjective and pronoun, and three classes of formal gender, its alphabet which like Greek and German would need transliteration into the more universal and therefore also more economical Roman characters. French would be dismissed because of the "French u," the nasals, the varying verbal forms, the grammatical gender, quite as annoying as the gender of three categories in the previously mentioned languages, inasmuch as the assignment of those categories is entirely arbitrary in each from the point of view of the others, and the irregular plurals, and the many fine distinctions which make complete mastery all but hopeless. Of Spanish and Italian much the same may be said. English is quite as much out of the question as any other language. A smattering of it, as of the others, is obtainable without great difficulty, but to learn it well, to overcome all of its difficulties, is another matter. English contains three consonant sounds peculiar to English alone, the *w*, the sound

represented by *th* in *with*, and the surd represented by the same digraph in *pith*. The accentuation is irregular and perplexing, while the orthography is hopeless. A half-dozen sounds may be represented by one letter or combination of letters, or one sound may be represented by as many varying signs.[2]

There are irregular verbs, about 175 in number, numerous irregular and defective plurals, and a want of clearness due to the fact that nouns, particles, adjectives, adverbs and verbs may have the same form, and that different tenses of the verb may be identical in form, whether or not identical in sound. There is also a more or less stereotyped and yet elusive word-order.

Any and all of the national languages are then out of the question, first because none can yet secure adoption even if it were suitable, and second, because none is suitable. To be capable of truly international use a language must be possible of complete acquirement by all, whether linguistically gifted or not, and must be possible of such acquirement in such short space of time as can be devoted to this by the majority of the busy citizens of the world. Its acquirement must be an incidental preparation for one's profession or business, not an end in itself, or a matter of higher culture for the few.

Hence the thought of modifying some one of these languages, or combining them, or in some way forming a neutral language, objectionable to none on political or sentimental grounds, easily mastered by all, and therefore recognized by all nations and races as the accepted medium for international communication. That it must appeal to all sufficiently to be thus accepted is an important item, for, as has been previously intimated, nothing of this kind can be forced into use. It must be such a language that every intelligent citizen of each nation can and will learn it, as the first language to be mastered after his mother-tongue, to be able to read it, speak it and write it, in his capacity as a citizen of the world, and as an intelligent citizen of his own nation.

Since the days of Descartes this dream has haunted one and another, and plans for such a tongue have been proposed, necessarily crude at first, gaining in value as time went on, and as each author of such a plan profited by the faults in the projects of his predecessors. The earliest attempts were to create a language of philosophical or *a priori* nature, in which words are reduced to mere formulæ, a certain letter of the alphabet indicating the concrete, another vegetable life, another animal life and so on. The idea, although wholly impracticable, has not yet entirely disappeared, and *a priori* schemes are still occasionally promulgated. One project, for example, has the following

[2] Note for example the different signs for the one consonant sound in ga*sh*, fa*shi*on, mi*ssi*on, co*nsci*ous, feti*ch*, na*ti*on, vi*ci*ous, etc., the different signs for the same sound in ra*z*e, ra*i*se, ra*y*s, ta*e*l, ga*o*l, ga*u*ge, gr*ea*t, fete, matin*ee*, *eh*, *ei*ght, th*ey*; the different sounds given to *ch* in *ch*arm, *ch*asm, *ch*andelier; the interchange of *s* and *z* sounds in lose, loose, azure, leisure, raze, race, erase, etc.

formations upon the letter *m: mab,* "mankind"; *mac,* "monkey"; *mad,* "cat"; *maf,* "dog"; *mag,* "bear"; *mas,* "horse"; *me,* "bird"; *mi,* "reptile"; *mo,* "fish," etc. Quite the opposite of these are the *a posteriori* languages, based upon the principle of borrowing, selecting and simplifying from already existing languages. This latter method, with a negligible admixture of the *a priori,* proves the only sound one, and all projects meeting with the slightest favor have been of this class. Among the numerous languages proposed, two alone have succeeded in obtaining any prominence or general publicity. The first of these was Volapük, published in 1880. Societies for its propaganda were organized, some instruction books and several magazines published. The success of the language, in spite of its crudities and too great difficulty, afforded proof that an international language was desired. But dissensions arose, chiefly as to whether numerous proposed changes should be introduced, with or without the consent of the author, who had assumed an unfortunate attitude of ownership of the language. By giving attention to discussion of such matters instead of to propaganda work, the Volapükists lost all they had gained.

Their bitter experience taught a lesson to the promulgators of the only other important project for an international language, the only one which to-day receives general attention. When overzealous theorists proposed changes in Esperanto, and insisted upon the adoption of their "improvements" the great majority of Esperantists refused to countenance any sudden or radical changes, declaring instead for a unity and stability. Their action was the more decisive in that the proposed improvements appealed to them as simply the marring of a language already proved satisfactory and practicable, and already existing as a living language, in which any changes should come gradually and systematically. The smaller restless and theorizing element attempted to create a schism through the use of various publications attacking Esperanto or Esperantists, and arrived at a somewhat unstable idiom of their own, which was called simplified Esperanto by some and a new language by others, among its advocates. A certain amount of newspaper notoriety was obtained in both Europe and America, but no definite or serious results.

The wisdom of the Esperantists as a whole is apparent in the progress due to their steadfastness and united effort. Those who know more or less of the language are reckoned by hundreds of thousands, judging by the number of text-books sold by responsible publishing houses, but the number of persons announced as being in the actual propaganda movement consists only of those who are registered and paying members of some official organization, such as the national associations, British, French, German, Japanese, American,[3] and various international or-

[3] Esperanto Association of North America, headquarters, 3981 Langley Avenue, Chicago.

ganizations, such as those of Esperantist physicians, scientists, pacifists, and many others. Propagated steadily but unobtrusively in all quarters of the world, the international language idea, represented by Esperanto, has loomed large and become a reality, even in this short space of time since its presentation to the world. Doubtless one reason is that the unbounded possibilities of the practical side of the language have only as yet begun to develop, while the insistence upon the ideals of "Esperantism" has been emphasized. This word Esperantism has come to stand for a spirit of tolerance and conciliation which is distinctly worthy of note, and which materially aids in paving the way for ultimate complete understanding and "the federation of the world."

It is a significant fact that the two nations which may be said to hold the linguistic balance of power, since their decision for the international language and their refusal to continue struggling with the manifold tongues of Europe, except for cultural purposes, would have great and well-nigh decisive weight, namely, the United States and Japan, were the two countries to send official *government* representatives to the last (fourth) International Esperanto Congress, held in Dresden, August, 1908.[4] For these two nations whose more and more intimate relations demand better mutual understanding and appreciation, as forcibly pointed out in the document previously mentioned, the most immediate and practicable method of obtaining such general and immediate intercourse lies ready at hand. The Esperanto movement, strongest in Europe, has found favorable reception in Japan, whose minister of foreign affairs is president of the Japanese Esperanto Association. In the United States the present propaganda association is less than a year old, yet the number and quality of persons interested in the idea and movement is such that European Esperantists expect to be invited to the United States for the Sixth Annual International Esperanto Congress, in 1910. It is to be hoped that this will come to pass, and that some educational institution of note will open its doors for the occasion, as did Cambridge University for the Congress in England in 1907. In the meantime, it certainly behooves every one who approves of the wide-spread international acquaintance, understanding and conciliation, to examine this language which offers such great possibilities, since it has proved itself fully worthy of consideration in the brief time that it has existed as a living language. It behooves every one to examine it, and to aid its promulgation as best he may, by advocating it, by urging its introduction into schools and publishing in it, entire or in abstract, at least some of the writings which he now offers to the reading public in English or some other national idiom only. For Esperanto is solving the problem of an international language, which is "An attempt to save the greatest amount of labor, and open the widest fields of thought and action to the greatest number."

[4] Cf. the report made by the U. S. delegate, Major P. F. Straub, of the U. S. Medical Corps, published in the *Army and Navy Register*, January 16, 1909.

WHAT IS A LIVING ANIMAL? HOW MUCH OF IT IS ALIVE?

By Dr. A. F. A. KING
WASHINGTON, D. C.

CONSIDERING the second question first, the reply to it will depend a good deal upon education. An extremely ignorant person might answer that all parts of a living body are alive except the bones. It required some education before we medical men learned to realize, without surprise, that crude metallic bodies—bullets, pins, needles, wire sutures buried in our internal organs, nails driven into our fractured bones by surgeons, finger rings, scissors, forceps, spectacles, etc., left in the peritoneal cavity by careless operators—could remain in a human body without any immediate danger to life.

We had to learn also that large crystalline masses—the various forms of calculi—and dead fœtuses; lithopodians; even dead children at full term, both intra- and extra-uterine—could remain in a living body for several decades without any immediate danger to life. Thus we learn from these crude examples that living bodies may contain dead bodies, and dead substances of various kinds. Numerous other instances will now be considered.

The protective shells of some animals, the epidermal appendages (horns, tusks, hoofs, claws, nails, hair, wool, etc.), of others, are only alive at their proximal ends—their "roots" so-called. Their distal extremities are not living. They are products of life, but so are our coal beds, chalk cliffs, coral reefs and tortoise shell combs, but they are not alive.

If we ask, Where is the line of division between the dead and living in a cow's horn, or an elephant's tusk, we must reply, there is no such line. The transition from living to dead tissue is a gradational one. And this simple example should help to dispel the common error that everything in this world *must* be either *dead or alive.* Not so. It may be between the two: neither one or the other. Here, if anywhere, the old truism, *Natura non facet saltem,* deserves special recognition.

We must certainly realize that the gases, foodstuffs and excrementitious matters in the alimentary canal and the contents of the urinary bladder are not alive. Is the bile living? Bile is an excrement from the hepatic cells, the histological units of the liver, which find it necessary to discharge their toxic excreta into those minute drains, the bile ducts, and thence into the main sewer of the intestine. In thus maintaining their own normal metabolism, they save us from hepatic toxæmia. Bile is not alive.

Is milk a living substance? It is a saline solution, containing sugar and albumen. Microscopically we find it swarming with the *post-mortem* débris of epithelium cells that have undergone fatty degeneration. It is the fatty dust into which these dead cells have crumbled that rises to the surface as cream and when amassed in the churn constitutes the butter of commerce. Milk is emphatically a dead material.

What of that milky emulsion we call chyle? We can not say it is alive in the intestine; nor does it become so in the thoracic duct, nor in the subclavian vein. Neither does mingling with the blood give it life. It is dead.

What of the blood itself? Commonly we speak of it as being "warm with life." Not so in cold-blooded animals. Again, it is referred to as the "vital fluid," the "life-blood"; and we say: "the blood is the life thereof." So it is, in the sense that we can not live without it, and if we lose it by hemorrhage we die. Nevertheless, the blood is *not* alive. Its corpuscles are, but the plasma in which they float is not living. This plasma is the natural *habitat* of the living corpuscle (much in the same way as a pond of water is the natural *habitat* of *Amœba proteus*), but it is not alive.

Can our blood corpuscles live in a dead plasma? It is not very long ago that in cases of hemorrhage we injected into the blood vessels large quantities of cow's milk; now-a-days we inject salt solution. In some cases we inject so much of these dead fluids that the quantity may exceed that of the normal blood plasma left behind after the hemorrhage. Hence we know by actual experiment, in these cases, that the larger part of the blood plasma mixture is not alive.

Furthermore, human leucocytes have been kept alive in normal salt solution outside of the body for many hours, retaining all their amœboid and phagocytic properties; and recently in a properly prepared solution containing 3 per cent. of sodium citrate and 1 per cent. of sodium chloride, R. C. Ross has kept human leucocytes three days alive and has caused them to protrude and retract the most remarkably long pseudopodia so that they actually resembled squids, or tarantulas.[1] Thus we see a living plasma is not necessary for the blood corpuscles: they flourish in a dead one. The blood plasma is not alive.

In the days of venesection we were taught that the last *act of vitality* in blood when drawn from the body was its coagulation, but is this really any more a vital process than the clotting of sour milk? I think not.

In the same category with milk and blood plasma, we must place lymph, the fluids in the pleura, pericardium, peritoneum and synovial sacs, and also the cerebro-spinal fluid; none of them is alive.

It might be supposed that the delicate structures of our central

[1] London *Lancet*, January 30, 1909, p. 314.

nervous system must at least be protected from contact with *dead* fluids. Not so. In cases of cerebro-spinal meningitis, we draw off the cerebro-spinal fluid and inject into the cerebro-spinal canal a curative antimeningitic serum that has stood on the shelves of its manufacturer, cold and dead, for half a year or more before being used.

In this line of thought we have reached the conclusion that the crystalline masses, gases and *fluids* in an animal body are none of them truly alive.

What have we left? What parts of the body *do live?* The histological units—the individual cells: these are the living inhabitants, in that great organic community, which constitutes a living animal.

The fluids of the body are inert plasmata designed for the maintenance, nourishment and functional integrity of these living units. The cells of the body are alive, but nothing else in it can be truly said to live.

Let us now ask: When an animal dies how much of it is dead? An ignorant person would reply: "All of it." Not so. The cells of a corpse remain alive some considerable time after the man has ceased to breathe. The cells of the liver continue their glycogenic function. Active spermatozoa have been found in the testicle, and living leucocytes in the cavities of the heart, many hours after death. The skin of a recent corpse can be successfully transplanted into a living person, as may also some of the internal organs, bones and joints. Recently one of our surgeons[2] has transplanted an entire knee joint (a healthy one) from the body of a corpse into the limb of a person from whom a diseased knee joint had been just previously removed. The case is progressing favorably.[3]

In the retrogressive phenomena of death as in the evolution of living from dead matter, the old saying of nature not making leaps, again asserts itself, and the prevalent error that everything must be either dead or alive, with no intermediate gradations, becomes pronouncedly manifest.

We now come to the question: What is a living animal? The one most marked characteristic of things that are truly alive is motion, especially locomotive auto-mobility, to which must be added growth and reproduction.

It is now generally admitted that the basis of life is electricity. The power that produces muscular motion, cell-movement, cell-division, cell union (as in fecundation), and embryological growth, is essentially a form of electro-magnetic energy, this energy being generated by the successive chemical decompositions and syntheses—the electrolytic asso-

[2] Dr. Tully S. Vaughn, of Washington, D. C.

[3] It is now six weeks since the operation. There have been a few similar cases in Germany.

ciations and dissociations of atoms and molecules—of anions and cations—in the complex phenomena of metabolism throughout the body. No nutritive change, even in a single cell, can take place without a disturbance of electric equilibrium and the development of an electric current, be it ever so diminutive. Nerve force, electricity and "vital force" are identical in so far as they are all manifestations of electro-magnetic energy. Every histological unit in an animal body is a diminutive battery in which such energy is evolved. This, I think, is common knowledge, that has passed beyond the realm of theory.

Perhaps the crudest and most evident illustration of the production of electricity by animal metabolism is exhibited in the electric fishes: the torpedo, the *Gymnotus* (electric eel), the *Malapterurus* (electric catfish), the skate and others. In these forms, it is true, we find a special electric apparatus, consisting of some hundreds of columns made up of millions of superimposed plates or discs, arranged transversely to the length of the columns and separated from one another by an albuminous liquid, thus resembling a voltaic pile. The distribution, or discharge of this electric energy is controlled by nerves emanating from the medulla oblongata. Thus the animal, at will, can shock and capture its prey, and even emit charges, in some instances, sufficient to injure, and perhaps kill, even men and horses.

A more delicate method of demonstrating the identity of nerve force and electricity was shown at the last meeting of the International Congress of Electrology and Radiology held in the University of Amsterdam,[4] when Professor Salomonson, by using Einthoven's string-galvanometer (a sort of electric microscope), was able to measure, and render visible on a photographic plate, the electric current producing one contraction of a single muscle, for example, that of the quadriceps femoris during the patellary reflex. Even currents producing contractions in the cardiac muscles were exhibited. He presented on the screen a cardiogram, by which, he remarks: "Each muscular fiber of the heart has written its own sign-manual on the photographic plate." By means of this device he was able to exhibit visibly events successively occurring at intervals of one one-hundredth of a second, and electric nerve currents so small as the one ten-thousandth part of a single volt.

Now if every living animal, and every cell within it, be really an electrical machine—a generator of electro-magnetic energy—it is evident that in order to secure and use the power thus produced the apparatus must be *insulated* from its surroundings, otherwise the electricity would instantly escape back into the earth whence it came. All our electric machines and batteries are thus insulated.

Are animal bodies provided with this electric insulation? They are.

[4] *Proceedings of the Royal Society of Medicine*, November, 1908.

The insulatory resistance of the bare human skin varies from 1,000 to 6,000 ohms. In many animals the insulation is increased by non-conducting hair, wool, fur, etc. And naked man finds it expedient to reinforce his own insulation by clothing of silk, satin, hair, wool, flannel and other non-conducting materials. We are exhilarated by a dry atmosphere: depressed by a damp one, because the moist air, being a conductor, carries off some of our electricity to the earth, while dry air is a more complete insulator and prevents this leakage.

Besides contact with the air, the *feet* of animals are in actual contact with the earth itself, and accordingly ought to be endowed with a specially good insulation.

Finding no data on this point, I submitted to the U. S. Bureau of Standards some specimens of a horse's hoof, to have their insulation tested. The director, Professor S. W. Stratton, wrote me[5] that the resistance of the first specimen, when dry, was 4,700 million ohms. This was a part of the "frog" of the foot. A second specimen, taken from the peripheral margin of the hoof was tested, of which the bureau reported[6] that "by the direct-deflection method, using 120 volts and a very sensitive galvanometer, the deflection was so small that it could not be read." "The resistance was equal to or greater than 22 billion ohms. This corresponds to a specific resistance of about 16.5×10^{10} ohms per centimeter cube." Professor Stratton adds: "Of course the actual resistance may be much higher, as it was too high to determine with any accuracy by this means."

Subsequently, Professor Chas. W. Mortimer, of the George Washington University, by using his Wheatstone Bridge apparatus, kindly tested for me, altogether, 67 specimens of animal and some vegetable structures, as to the insulating power of their external coverings. The specimens included the feet, claws and bills of sheep, rabbits and chickens; the fresh human umbilical cord, fœtal membranes and placenta; the shell of an egg; the external coverings of fruits (oranges, apples, nuts, etc.) and of vegetables (turnips, onions, etc.).

In no instance did the external covering fail to exhibit a relatively greater resistance than the internal structure. In most of the specimens the resistance hovered about 10,000,000 ohms, some more, some less. In one instance, that of a green pea pod, the resistance of the unbroken pod was 500,000 ohms, while the external surface of the green pea itself was 10,000,000 ohms.

I did not test any cereal grains, but Mr. Lyman J. Briggs, of the Bureau of Plant Industry, U. S. Department of Agriculture, has recently ascertained that the resistance of wheat grains, varying with

[5] Official letter, October 23, 1903.

[6] Official letter, January 21, 1904.

temperature and moisture, is somewhere between 2 million and 10,000 million ohms.[7]

It is conceivable that the grains of wheat exhumed with Egyptian mummies would scarcely have retained their germinating power after so many centuries had not nature clothed them with their insulating shells, and passing from these diminutive little lives of eggs, grains and cells, it is conceivable that this globe that we inhabit would itself become a moving sepulchre, devoid of all molecular transformations of energy, were it not for the external envelope of insulating atmosphere with which it is clothed. Without this insulation the energy of solar light and heat would no longer be transformed into things of beauty and life; but would at once be dissipated into the abysses of space and our earth would probably become as dead as the moon, which has no insulating covering, and, consequently, upon whose face, within the memory of man, no single change of feature has been observed.

In the foregoing discussion my purpose has been to lay the foundation for a modified definition of life. Every one is familiar with Spencer's definition, viz:

> Life is the definite combination of heterogeneous changes, both simultaneous and successive, in correspondence with external coexistences and sequences.[8]

Never, perhaps, did human language attempt to express so much in so few words. In fact it is so condensed as to be difficult of comprehension. If the definition had been given first, few of us would ever guess that life was the thing it intended to define.

On page 80, Spencer says:

> The broadest and most complete definition of life will be: the continuous adjustment of internal relations with external relations.

De Blainville said:

> Life is the twofold internal movement of composition and decomposition at once general and continuous.

Criticizing this definition, Spencer remarks:

> It describes not only the integrating and disintegrating processes going on in a living body, but it equally well describes those going on in a galvanic battery which *also* exhibits a two-fold internal movement of composition and decomposition at once general and continuous.[9]

At the time Spencer wrote (1866), biology was not sufficiently advanced for him to realize that every cell in the body really *was* a minute electric battery, and that the coordinate and simultaneous action of millions of these batteries made up together the living body of a complete animal.

[7] *Science*, December 4, 1908, p. 812, and Bulletin 99, 1907, Bureau of Plant Industry, U. S. Department of Agriculture.

[8] "Principles of Biology," p. 74.

[9] "Principles of Biology," p. 60.

With these preliminaries, I submit the following definition of a living being. It is this: A living body, whether a simple cell or a fully developed mammal, consists of a temporary aggregation of a limited number of material particles, call them what we may—molecules, atoms, ions, electrons—whose actions and reactions between each other, and between themselves and their environing conditions (light, temperature, air, water, food, terrestrial magnetism, gravitation, etc.) are of such a kind as to generate electro-magnetic energy, which energy *is* and necessarily *must* be secured to the use of the individual producing it, by a semi-porous limiting external envelope which provides the individual with *electric insulation* from its surroundings.

It is upon this *external electric insulation* that I desire to insist as a necessary part of everything that can truly be said to "live, move and have its being." Vain and useless indeed would be the energy generated in living bodies by the successive compositions and decompositions, the integrations and disintegrations, the electrolytic associations and disassociations of ions and electrons resulting from animal metabolism, if no arrangement had been provided by which the energy developed could be secured to the use of the individual producing it, instead of instantly flashing back to the earth whence it came, which it inevitably would do, in the absence of such insulation.

That this insulatory covering really exists, in the case of animals, eggs, seeds, etc., has been shown by the experiments before mentioned.

That the individual cells of the body—the histological units—are also provided with the same electric insulation, may be more difficult to demonstrate. But such demonstration is not altogether wanting. The red corpuscles of the blood are, in a measure, insulated from the serum in which they float. "The intact red corpuscles," writes Stewart, "have an electric conductivity so many times less than that of serum that they may, in comparison, be looked upon as non-conductors."[10] Among other explanations he suggests that this may be because the envelope of the corpuscles refuses passage to the electric charge produced by the dissociation of ions within them.

In the developing ovum, according to this view, the ectoderm ought to be an insulator. I can give no proof of this, but it is significantly suggestive that the cerebro-spinal axis of the embryo (which we should think ought to receive a specially good insulation) is clothed on its outside by an investment from the ectodermic layer, produced by an invagination of that structure to form the medullary groove and canal in which the central nervous system pursues its development.

Finally, is the protoplasm of animal organisms a really living substance? The answer will depend upon our definition of the word

[10] "Human Physiology," p. 35, 3d ed., 1899.

"living." Properly speaking, protoplasm is neither dead nor alive: it is between the two.

If we could get together an ounce or a ton of it, we should say it was a substance or mass exhibiting *some of the properties* of living matter. We could not say it was a living individual. It is simply matter occupying a very high plane in those ascending gradational transformations between the dead and the living: between the simple inorganic constituents of the earth, and those more complex segregations of chemical atoms which finally become surrounded by a limiting insulatory envelope and thus constitute "physiological units," or living beings. But until this formation of units—this individualism— of the mass, protoplasm can not be said to live.

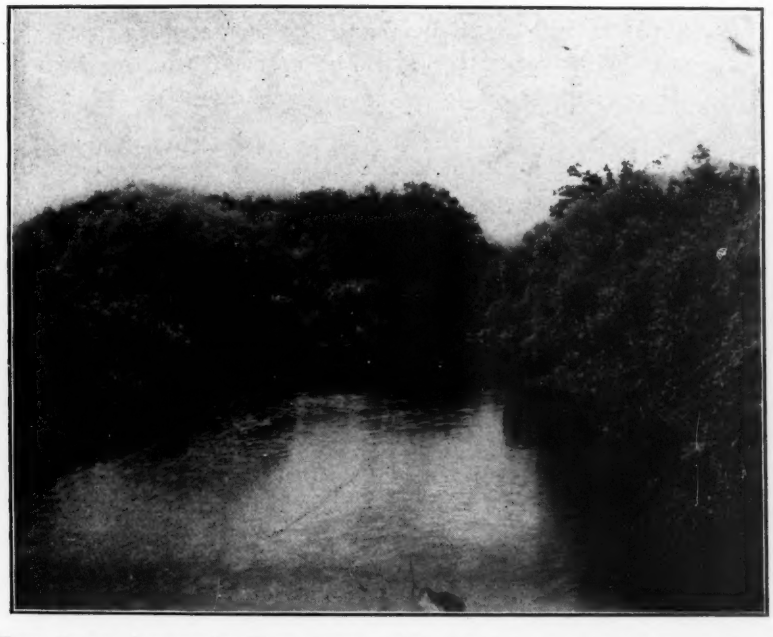
Of course, the *direct* transformation of *in*organic matter into living *animal* matter is impossible. There must always occur the intermediate phenomenon of vegetable life. Vegetables *can* transform the inorganic chemical materials of the air and earth into their own structure, but the animal must either feed upon the products produced by the vegetable or upon other animals that have been so fed. No single definition of life, therefore, can include both animal and vegetable life, since the vegetable is an intermediate product between minerals and animals. The evolution of life is a gradational process. Things are *not* "either dead or alive." Some things, like protoplasm, are between the two.

ABANDONED CANALS OF THE STATE OF NEW YORK

By ELY VAN DE WARKER

THOSE who have only a partial knowledge of the subject, regard the present time as the age of canals. They overlook the generations of time and the vast sums of money expended by other people who have held to the idea of the canal with a national fixity of purpose that has produced astonishing results. The amount of money expended so exceeds the sums spent in the United States, including the Isthmian Canal, that they appear like trivial things.

France has 3,045 miles of artificial waterways and 4,665 miles of canalized rivers, aggregating nearly 8,000 miles. These cost in the last thirty years five hundred million dollars. Belgium has one mile of canal navigation to eight miles of territory. Germany has spent, since 1900, eighty million dollars and has just authorized the expenditure of eighty-five million dollars more. Austria-Hungary within a few years has expended fifty-three million dollars and is yet pushing the work. The canals of Holland and some of those of southern France were built centuries ago.



FISH CREEK, OPENING OF WOOD CREEK, which will be a part of the Barge Canal.

WOOD CREEK, THE OLD CANAL, 1795.

These countries are achieving commercial supremacy along lines that parallel the development of their canal systems. One of the most interesting features of international political economy is the great value one nation will place upon a thing that another people will throw away. What makes the canals of France of such value to the people is their contentment in saving money. The Frenchman has a keen sense of the value of a dollar saved. So long as he can get the product of his acres and the output of his factories at their final destination at the lowest freight cost, without time as an important factor, he is content with canal transportation. He realized that a dollar so saved is to be totaled among his profits and not credited to his savings.

The American, working on the credit system, is obliged to earn the quick dollar, and yet feels the attrition of the nether millstone that gives to the corporate trusts the money that belongs to the small producer. He thus abandons canals that in France would pay the individual as well as the state. The American has but one standard, Do the canals pay? He demands immediate returns, not prospective. Canals have their good and bad years. With such a criticism no canal, as a tax earner, is always successful. This, in brief, was the history of the abandonment of the central New York canals. It is interesting to trace this cause in the profligate dereliction of the lateral canals.

The state engineer's report shows the abandonment of 221 miles of canals with their locks and feeders. To this, add a littoral of lakes and rivers of 300 miles and we have abandoned waterways of 521 miles. This covers a region which, in the course of thirty years, has increased 1,500,000 in population and its manufactured products have more than trebled.

The American voter is not the wise man that he thinks he is. He fails to grasp the primary idea of statecraft. He bends an obedient knee to the moloch of the lobby. He obeyed the behest of his party and sold his birthright for something as impalpable as moonlight. When he sold the right of way of the Chemung Canal for $100, he saw neither wrong to himself nor injustice to his posterity. A few dollars of annual tax was worth more than millions in prospective.

For years it was a vexed question in politics, with the democrats on one side and the republicans on the other. The fatal blow was given in the republican stronghold, central New York, by the people who had the most at stake in preserving the canals.

The republican legislature of 1873 officially abandoned them. The results were quickly shown. The year before the abandonment gave a loss in tons of 308,588, while two railways connecting Lake Erie with New York showed an excess in tons of freight over that of 1872 of 1,877,187. This was a direct loss to the farmer and the small producer of $96,693 to save the small sum of $34,000 divided among sixteen counties. A more complete demonstration of the canals as a freight regulator it would be impossible to find.

ONEIDA LAKE CANAL LOCKS.

The result to the farmers was a harder blow to bear. Real estate value shrank to less than was paid for land forty years before. Central New York was the great wheat-growing region of the state, but by the rapidly moving freight of the railways they were unable to compete with the western wheat. This lost crop was so nearly total that they ceased to grow enough for their own mills. It appears as though they ought to have had business foresight to realize the value of the lateral canals as coal carriers. It was for this purpose that these canals were built.

They awoke from their dream of small economy to find themselves in the grasp of the great octopus of the coal roads, which for thirty-five years has been growing more exacting and oppressive. Throughout this region these roads are not only drawing the coal, but by their own agents they are delivering it at the door of the consumer.

We have been laying this upon the farmer and the people directly interested in maintaining these canals, and justly. There never was a moment when the mass of voters in this republican stronghold could not have dominated the situation. It was the old time-worn adage of a fool and his folly. He has not the negative merit of holding his tongue after he has committed the error. Utica, which could have saved the Shenango Canal, petitioned the state engineer's office and the canal board for the rebuilding of the canal as a coal carrier only a year ago. It was a childish effort and they awoke from the calm repose to find that their fair city was simply reduced to a state of mind and the real Utica was the Lackawanna road.

Before the Erie Canal was a practical waterway the people were keenly alive to the value of the lakes as commercial waterways. The earliest steamboat navigation as a well-developed enterprise upon inland waters was opened in the New York lake region. Upon three of the lakes—Cayuga, Seneca and Keuka—steam navigation appeared in 1820. The people were roused to enthusiasm. The first boats made their landings amid the shouts of the multitude, volleys of musketry and salvos of cannon. Gradually the steamboat service was extended until in 1827 steamboats were a general thing upon the lakes. Many years previous to this sloop navigation was resorted to for both freight and passengers. The first began regular trading trips in 1795 and gradually this form of navigation was extended over all the lakes.

The Erie Canal found abundant supplies of freight and passengers waiting when it passed through this region of the lateral canals. As a method of commercial interchange they never paid; whatever we may think about the ethics of the state making money off the people's enterprise, there was no question about its rights as late as 1873. Neither was any money lost until the people followed like a flock

of sheep the bell wether, the political factotum of the countryside, and surrendered its rights to the railways. The face of the country withered, as though stricken by a famine, under their remorseless demands. The fact that makes canal navigation not alone possible but profitable is that speed represents cost.

That which constitutes a profitable canal is not a dividend on the investment, but in augmenting the volume of trade. The profit that accrues is prospective, not immediate, and belongs to the people; a theory of public utilities that the state of New York never adopted.

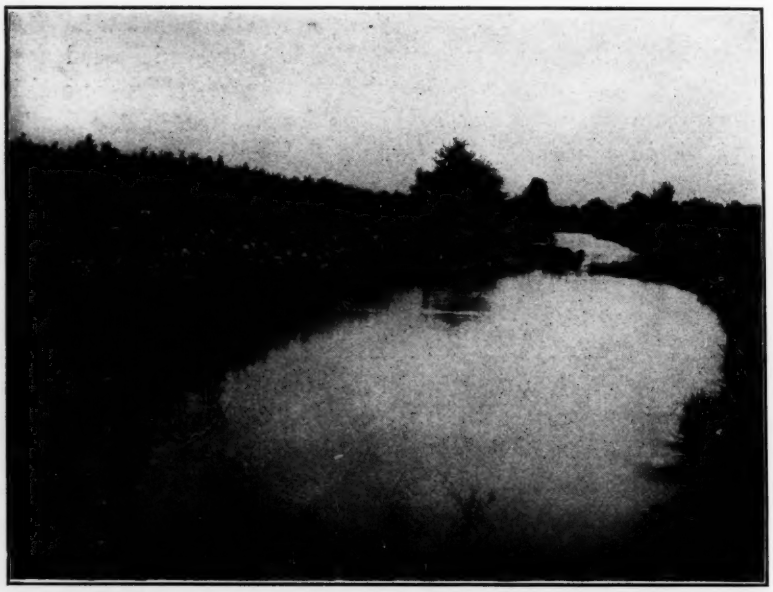
Let us see what this meant to the farmer and the manufacturer. The manufactured product was of coarsest character, hoops, staves, shingles and sawed lumber, material that could not afford to pay a higher tariff for transportation. This was practically cut out. Farm produce was of a like character; potatoes, cabbage, onions and apples demanded a moderate price for carriage if they were to make a living return to the grower. These were no longer seen by the boatload except within wheeling distance of the Erie; a small supply was received from the Cayuga and Seneca canals. The wheat crop, as already noticed, had disappeared. Barley and oats, in the cheap days of 1870, represented little money to the grower, and hay at six and seven dollars a ton, including the cost of baling, was impossible as freight. It was reasonable to expect that the roads would not work against these products an impossible tariff. The way station received but little notice. It was the fatal long haul, that has caused so many crimes against commerce, that was at fault. It cost more to stop and side-track than to make the continuous trip.

In 1872 the amount carried was 156,999 tons. This did not represent much in commercial value. But, this was only a minor part of its true worth. Imagine the condition had the slight sacrifice been made of maintaining the lateral canals for the past thirty-five years, with over 1,500,000 population added. These derelict canals would have been a treasure-trove to the inhabitants. An English author upon the subject expresses the idea perfectly when he states "that where canals do not pay, they pay by increasing the volume of trade."

The coal transported by lateral canals was 411,918 tons, sufficient to compel the roads to meet the cheap water rate. An instance on the Black River Canal, now used as a feeder to the Erie, illustrates what happened to the people of the lake region. The last station on the canal paid at retail three dollars a ton for coal; the town above, served by the railroad, paid five and a half per ton. The saving on freight, in thirty-five years, had the canals been the rate maker, would have amounted to more than a million and a half dollars yearly.

The waterways of the Iroquois were, from the nature of their distribution, natural waterways; while the Erie connected two termini.

The freightage was the natural product of its own littoral. The demand for canals was so urgent that as early as 1768 it was designed to connect Oneida Lake and the Mohawk by the improvement of Wood Creek. In 1792 the legislature passed the act. To this day old wooden locks may be found upon Wood Creek. Central New York was the first stimulus to the canal system of the state. It paid even at that early date. It reduced the cost of transportation from $32 to $16 per ton on the cargo. This great reduction in price "actually doubled the intrinsic value of the lands and produce around our lakes."[1] If the reader were able to see the insignificance of the little ditch of Wood Creek he could not realize the grand total of the result.



OLD ONEIDA LAKE, WOODEN LOCKS.

A few details will prove that the cheapening of carriage and the earning capacity of the canal was under- rather than over-estimated. The toll on a barrel of flour passing 100 miles was 52 cents and for a ton of goods passing the same distance was $5.75. The rapidity with which its earning capacity increased is not less remarkable. The capital stock of the western company was $232,000, which paid to the stockholders a dividend of 3 per cent. in 1798, 3.5 in 1813, 4.5 in 1815 and 8 per cent. in 1816.

The rights of this company were acquired by the state in 1820, for $151,000. The middle division cost $1,125,983. If we add to this double the amount for enlargement, the sum of $2,570,000 was

[1] State Engineer's Report, 1862.

abandoned by the state, the result of an ignorant and weak constituency and an aggressive lobby who represented the powerful railways behind the movement. These canals will be rebuilt on a grander scale commensurate with the magnitude of the barge canal. Already some of the great inland lakes have applied for a renewal of the canals. The history of the lateral canals will insure a favorable response. Even then they will not be money-makers. They will make money for the state only in proportion to the trade developed.

It is doubtful if the history of the country can parallel such useless destruction. From the amount of money squandered and the human

ONEIDA CANAL.

interests involved, it stands alone, not as an object of public plunder, but, worse than that, a colossal blunder.

In going over these old canals it appears among the marvels of time, how quickly they are disappearing. Stones of monolithic size are lying in heaps. Canals, like the Chemung, are simply weed-grown ditches. Wooden locks have left scarcely a trace; ruin, measured by the hundreds of miles, disfigures and encumbers the earth.

The Genesee Valley was one of the most important of the subsidiary canals. During the year previous to its official abandonment the total movement of goods amounted to 96,000 tons, in a total of nearly a half million. In 1873, 132 tons of wheat and 245 tons of

CHEMUNG CANAL.

CHEMUNG CANAL EXTENSION.

flour moved in the direction of tide water. The total of tolls in the last year of its official life was over 20,000 dollars. The story of the coal moved is better told in the amount carried by the Cayuga and Seneca Lakes Canal, and partly distributed by the Genesee Valley, which was 400,000 tons, now reduced to a few boatloads to accommodate the railroads and not the public. There could not possibly have been serious loss to the state from the Genesee Valley Canal and yet it passed the way of the other waterways. This canal offers the most picturesque ruins. A railway runs along the bottom for a part of the way. The remains of the works at Dansville have a kind of melancholy grandeur; a sad evidence of the greed and folly of man.

It is only a matter of time when the subsidary canals will be rebuilt. With the increased value of material and labor, it will cost hundreds of thousands while the original represented thousands. It will not be a question of money. It will be an overmastering impulse to equal the best in canal structure. France, Germany, Belgium, Holland will be the criteria. There appears every prospect that the roads will take their normal place as freight carriers.

It is planned to build a canal from the great lakes to Pittsburg, thence to the Gulf. Such a waterway, if constructed with a view of paying interest on the investment, will never be built. As a check to the greed of the railways, as a plan to place them in normal accord with the transportation interests of the country, it will prove an unalloyed blessing. Of more value than all else will be the vast tide of traffic that will seek the cheap route of the canals. Seen from this point the canals will always pay. The lateral waterways of New York, in their darkest hour, paid the people manyfold. The sin of the abandoned canals rests to-day upon this charming region. The fleets of steamers, sloops and barges have disappeared and the lakes have drifted back to primeval solitude.

THE PROGRESS OF SCIENCE

TENNYSON AND THE SCIENCE OF THE NINETEENTH CENTURY

THE hundred years which began with the births of Darwin, Tennyson and Gladstone, and closes with the deaths of Meredith and Swinburne, has been a notable period in English history. Its two chief movements—the growth of science and the growth of democracy—are adequately represented by Darwin and Gladstone. Tennyson was the most widely read and perhaps the greatest poet of the period. The scientific man may be permitted to moralize over the world-wide extension and permanence of Darwin's contribution as compared with Tennyson's. Fifty years ago Darwin's name was almost unknown, whereas Tennyson's was a household word in England. A little later a man was not thought to have made himself ridiculous by saying that he sided with God against Darwin and the devil. Now Tennyson's reputation is being defended; no one would think of defending Darwin. The University of Cambridge lavishes its academic ceremonial on the man of science rather than on the poet. Tennyson wrote:

> The man of science himself is fonder of glory, and vain,
> An eye well practised in nature, a spirit bounded and poor.

But Darwin's personality and character are comparable with his services to science.

We may place the science of the nineteenth century before its poetry and Darwin before Tennyson; but to do so it is not needful to depreciate the poetry or the poet laureate. Indeed a scientific journal may well call attention to the fact that Tennyson was largely influenced by the science of his period and permitted it to become part of his poetry. Poetry based on the classical tradition can not make a wide or deep appeal to a world in which it is no longer living; the future of poetry depends on the possibility of its adjusting itself to science and modern life, and Tennyson should receive honor for his efforts to this end.

The well-known verses of "In Memoriam" were printed nine years before the "Origin of Species." The geology may have have come from Lyell, but it was twenty years before Lyell would have been willing to accept the last verse of the stanza:

> The solid earth whereon we tread
> In tracts of fluent heat began,
> And grew to seeming random forms,
> The seeming prey of cyclic storms,
> Till at the last arose the man.

The doctrine of evolution is frequently used, as in "Maud," where the first verse is scarcely less significant than the second in the couplet:

> As nine months go to the shaping an infant ripe for his birth,
> So many a million of ages have gone to the making of man.

There will also be found in Tennyson an adequate conception of physical science and an attempt to put even its practical achievements into poetical form. Thus the age is told to

> Rift the hills, and roll the waters, flash the lightnings, weigh the sun.

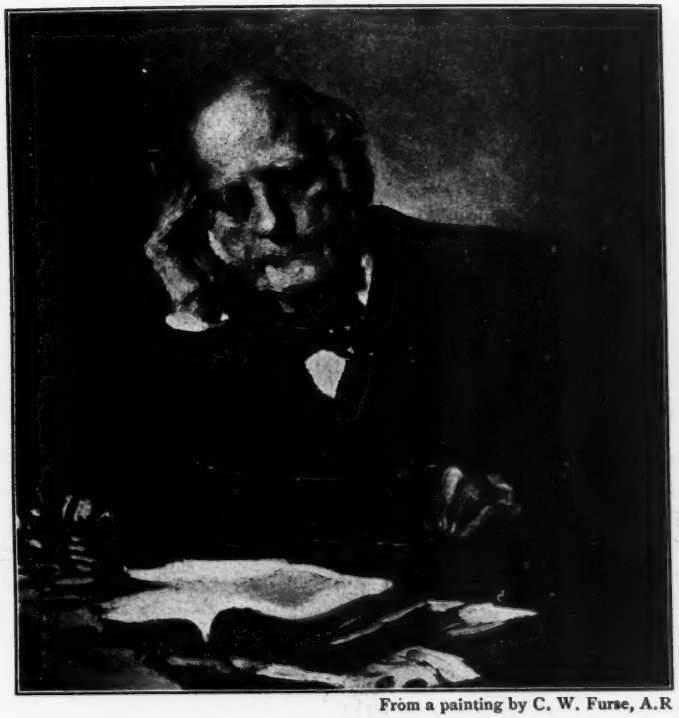
and we even hear of

> The nations' airy navies grappling in the central blue.

Scientific knowledge is assumed or taught continually in the pages of Tennyson from the first lines of the "Lady of Shalott," which reawakened the spirit of English poetry—

> On either side the river lie
> Long fields of barley and of rye . . .
> Willows whiten, aspens quiver
> Little breezes dusk and shiver.

to his last poem with



From a painting by C. W. Furse, A.R A.

Yours faithfully
Francis Galton

the kindly sphere
That once had rolled you round and round the sun.

Medievalism and modern life, classical reference and scientific simile are curiously commingled in Tennyson's poems. As one turns back to them "the tender grace of a day that is dead" does not fully return. They are not like science universal; but for their own epoch they were not only great poems, but also rendered a not insignificant service in the diffusion of the scientific spirit.

THE REMINISCENCES OF SIR FRANCIS GALTON

THE greatness of the Victorian era is now represented among the living by men of science—Hooker, Wallace, Avebury, Lister, Huggins, Galton—all past eighty years of age. Sir Francis Galton—the "sir" is a tardy recognition on the king's recent birthday—now in his eighty-eighth year has done well to prepare the reminiscences which have been published under the title "Memories of my Life." He is typical of the great period in which he has lived and to the preeminence of which he has contributed his share. Like his cousin, Charles Darwin, he has had no profession, but with sufficient private means he has devoted his life to the advancement of science. There are certain marked resemblances in intellect and character between the two kinsmen—scientific curiosity reaching from obscure details to broad theories, patience combined with daring, royal simplicity and directness—which might be used to illustrate the theories of heredity in which both have been interested. Galton, like Darwin, studied medicine and like him was a student at Cambridge; but, unlike Darwin, he has lived in London and has taken an active part in the social and scientific activities of the time. He has been in intimate personal relations with the scientific and other leaders and a helpful friend to many at the beginning of their scientific work. The writer of the present note is one of a large company that owes him an unpayable debt for personal kindness and intellectual stimulation.

Galton—the Sir Francis does not come naturally—gives rather full details, as is becoming, of his parentage and early life. On both sides he was of quaker stock. He traces to inheritance his taste for science, for poetry and for statistics, and his endurance of physical fatigue. His formal schooling was not profitable. He says (it was before going to Cambridge): "In the spring of 1840 a passion for travel seized me as if I had been a migratory bird." He made a somewhat adventurous trip to the near east, and his travels were continued more seriously on completing his studies. He made two trips of exploration in Africa, in the second conducting an expedition of some 1,700 miles through unknown regions in the southwest. For this he was awarded one of the gold medals of the Royal Geographical Society in 1854, and was elected a fellow of the Royal Society two years later.

In 1853 Galton married a daughter of the dean of Peterborough, the father of a gifted family, and thenceforth residing in London carried out the investigations and published the long series of important memoirs and volumes, the contents of which are all too briefly reviewed in the reminiscences. First appeared works on travel, then serious attention was given to meteorology and the Kew Observatory. In 1865 were published two papers on "Heredity Talent and Character"; and these were followed by the studies on variation and individual differences which are largely summarized in "Human Faculty." The work on anthropometry, on association and on imagery opened up new fields for psychology; the composite portraits and the study of finger prints are known to all. Nearly every one of the 183 publications contains a new idea or an ingenious application. The work on

heredity and its application to eugenics, beginning before the publication of the volume on "Hereditary Genius" in 1869 and continuing to the present time, is of vast importance. Numerous articles on these subjects by Galton himself and by others who have received their inspiration from him have been published in this journal, and it is of course out of the question to give a summary in a brief note. There are no other problems so important as those to which Galton has given the name eugenics, and there is no one else who has done so much toward making straight the way for their solution.

THE EUGENICS LABORATORY OF THE UNIVERSITY OF LONDON

AMONG Sir Francis Galton's unnumbered services to science has been the establishment of a laboratory for the study of national eugenics at the University of London. In cooperation with the biometric laboratory and the department of applied mathematics, also under the direction of Professor Karl Pearson, it is leading the way in a movement likely to become dominant in the course of the present century. National eugenics is officially described as "the study of agencies under social control that may improve or impair the racial qualities of future generations, either physically or mentally." It is further stated that it is intended that the laboratory shall serve as a storehouse of statistical material bearing on the mental and physical conditions in man, and the relation of these conditions to inheritance and environment, as a center for the publication or other form of distribution of information concerning national eugenics, and as a school for training and assisting students in special problems in eugenics.

The general scope of the work which has been undertaken may be gathered from an enumeration of the publications for which the laboratories of the University of London are responsible. *Biometrika* is a journal for the statistical study of the biological sciences published about four times a year and now in the seventh volume. It is a storehouse of materials and methods, dominated naturally by the interests of the editor. In some ways it is an advantage and in some ways a drawback that Professor Pearson is a mathematician. The need of applying mathematical methods to variation and heredity should be emphasized and stress on the method has permitted the treatment and unification of varied material. But it is also true that so long as there are but few biologists who are mathematicians, there is danger that certain methods may become prematurely crystallized and these special methods may be regarded as an end rather than as a tool. In addition to *Biometrica* there has been established this year a *Treasury of Human Inheritance*, devoted to family histories, including diseases, physical traits and mental qualities. Then there are two series of memoirs, one entitled *Biometric Series*, the other *Studies in National Deterioration*, published at the expense of the Drapers' Company. The first of these contains chiefly Professor Pearson's more recent mathematical contributions to the theory of evolution, while the second includes so far three studies, one on the relation of fertility in men to social status and two on inheritance and infection in tuberculosis. Lastly, there is a lecture series, of which but one has been issued, and a memoir series from the eugenics laboratory. The memoirs include a study of the inheritance of ability from the Oxford class lists and of the relation between success in examinations and in after life; inheritance of insanity, the resemblance of first cousins and the inheritance of vision.

THE INHERITANCE OF VISION

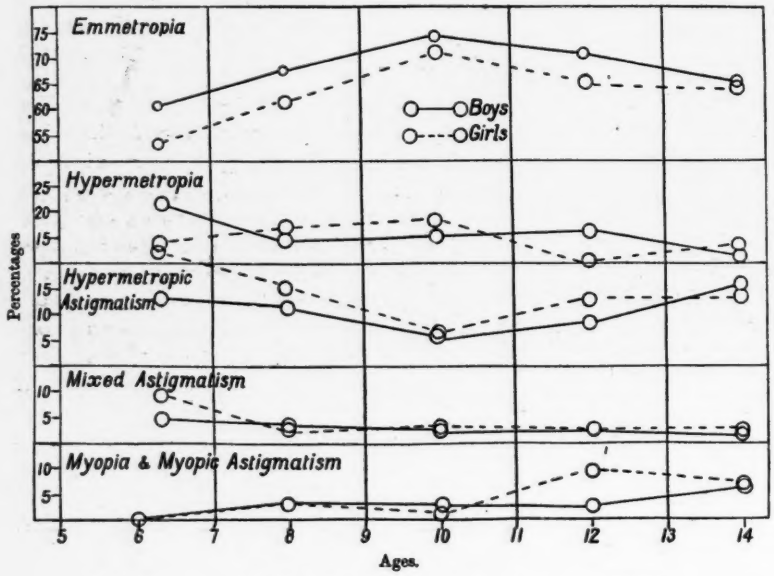
THE recently issued monograph from the Eugenics Laboratory on the in-

heritance of vision, which is by Miss Amy Barrington and Professor Karl Pearson, is of special interest, as it is one of the first attempts to determine the relative influence of heredity and environment, and announces the unexpected conclusion that there is no definite evidence that schools have a deleterious effect on the eyesight of children. Other results are that keenness of vision is an inherited character, that there is some relation between intelligence and good eyesight, but none between this and poverty or shiftless parentage.

The authors have not obtained data of their own, but work over results that have already been published. For heredity they discuss the work of Steiger, which has the drawback that the material is not a random selection from the population, but starts with abnormal cases. Allowing for this, they conclude that heredity is as strong in the case of astigmatism as for other physical traits, such as height or eye color.

For environment the authors depend largely on a study of 1,400 school children made by the Edinburgh Charity Organization Society. These children show a high degree of fraternal resemblance. The conditions of eyesight are reproduced in the accompanying diagram. It appears that emmetropia —which the authors regard as synonymous with normal vision, though there are good grounds for regarding the hypermetropic eye as normal— actually increases from the age of six to ten, while astigmatism decreases. There is no appreciable change in myopia. Myopia, or near-sightedness, does increase from the age of ten to fourteen, though only to 6.5 per cent. of the children.

These figures do not agree with those of Cohen, Erismann, Risley and other investigators. Cohen, for example, found the percentage of myopics to be: in village schools 1.4 per cent., in elementary schools 6.7 per cent, in intermediate schools 10.3 per cent., in the gymnasium 26.2 per cent. and in the university 59.5 per cent. The fact is that the Edinburgh children, being from the poorest classes, probably did not greatly strain their eyes with reading and school work. The authors say: "The persistent use by the Ger-



THE DISTRIBUTION OF EYESIGHT AMONG EDINBURGH CHILDREN.

DR. ERNEST FOX NICHOLS

President of Dartmouth College, lately Professor of Physics in Columbia University.

mans of non-hygienic characters for their type . . . renders all comparisons of English and German conditions unprofitable." One might suppose, on the contrary, that this comparison would indicate that progressive myopia is due to environment rather than to heredity. Cohen indeed found that of 1,000 near-sighted children only 2.7 per cent. had a near-sighted father or mother.

Professor Pearson may be correct in urging that "the first thing is good stock, and the second thing is good stock, and the third thing is good stock," but it does not appear that this conclusion can be deduced from what is known in regard to defective eyesight. There is danger that an attitude such as Professor Pearson's may lead to neglect of those factors of the environment which we can improve. When he says: "Pay attention to breeding, and the environmental element will not upset your projects," he rather neglects to emphasize the fact that paying attention to breeding does not under what Galton calls "the existing conditions of law and sentiment" give us much chance to improve the racial stock in man. We can not breed a race immune to myopia, but we can refrain from producing a generation of myopic school children.

SCIENTIFIC ITEMS

WE regret to record the death of Dr. R. E. C. Stearns, of Los Angeles, known for his work on the Mollusca; of John Morse Ordway, until recently professor of metallurgy at Tulane University; of Mr. Lefferts Buck, a leading New York engineer; of Dr. T. W. Bridge, professor of zoology at Birmingham, and of Dr. V. R. Matteucci, director of the Observatory on Mt. Vesuvius.

PROFESSOR R. C. ALLEN, of the University of Michigan, has been appointed state geologist of Michigan, to succeed Dr. A. C. Lane, who has become professor of geology in Tufts College.—Dr. C. Gordon Hewitt, lecturer in economic zoology in the University of Manchester, has been appointed entomologist to the Dominion of Canada in succession to the late Dr. James Fletcher.

SIR JOSEPH DALTON HOOKER celebrated his ninety-second birthday on June 30. His scientific career began seventy years ago, when he went out as surgeon and naturalist with Sir James Ross's Antarctic expedition.—Dr. C. Lloyd Morgan, F.R.S., known for his contributions to comparative psychology, has resigned the office of vice-chancellor of the University of Bristol.

THE French Association for the Advancement of Science will meet this year at Lille on August 2–7, under the presidency of Professor Landouzy, dean of the faculty of medicine in the University of Paris. The gold medal of the association, which was instituted last year, is to be awarded to Professor H. Poincaré, who will deliver a lecture during the course of the meeting.

THE heirs of the late Herr Heinrich Lanz, head of the Mannheim engineering firm, have given a million Marks for the establishment of an academy of science at Heidelberg.—M. Henry Deutsch has given 500,000 francs, and promises in addition an annual grant of 15,000 francs, towards the creation of an aerotechnical institute in the University of Paris. M. Basil Zakaroff has given 700,000 francs for the foundation of a chair of aviation in the faculty of sciences of the university.